ISIS

INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

GUT REACTIONS

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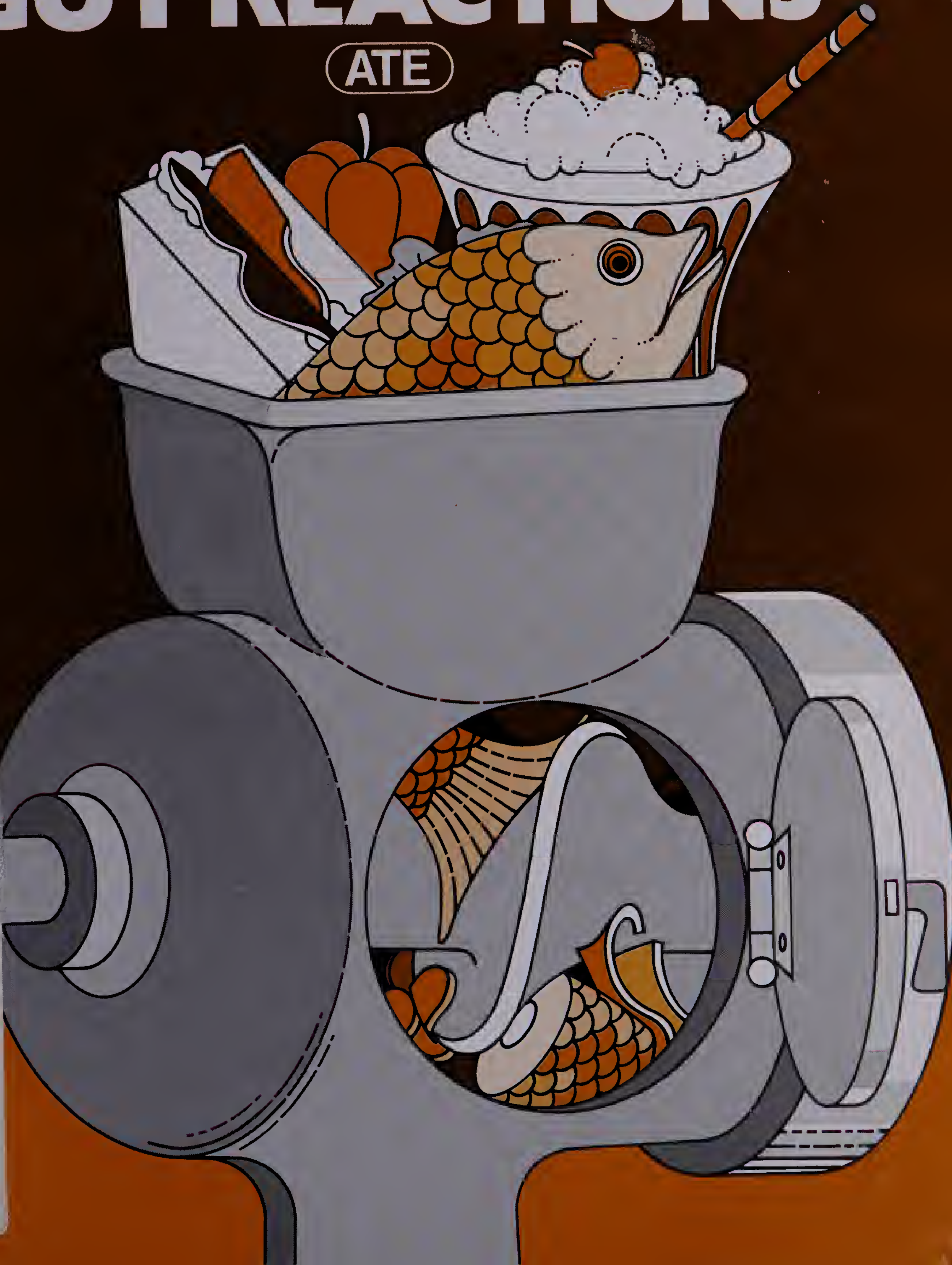

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GUT REACTIONS

ANNOTATED TEACHER'S EDITION

Ginn and Company

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CONTENTS

Overview

Digestion is a lifelong, continuous process, usually unnoticed when it goes smoothly and often distressing when it does not. The importance of a well functioning digestive system might be gauged by the number of advertisements for products to relieve everything and anything from toothache to constipation. Most food must be processed in some way by the digestive system before it can be used by the body.

Gut Reactions focuses on the digestive system and its processes and common gastrointestinal disorders. The topics range from the release of digestive juices and the absorption of food into the body, to the action of catalysts in chemical reactions and the treatment of common diseases of the digestive tract. Helpful information is included on the prevention of tooth decay.

Organization

This minicourse contains fourteen activities; seven in the core section, four in the advanced section, and three in the excursion section. The planning activities must be done first in each section. In addition, any students who find that they need to do Activity 2 should do it before any of the remaining activities, and any students who need to do Activity 7 should do it as the last activity before moving on to any advanced or excursion activities. Activity 2 gives an overview of the digestive system and introduces many of the terms used in the rest of the activities. Activity 7 introduces metabolism and some of the glands and hormones involved with metabolism. Also, any students who need to do Activity 9 should do it before the other advanced activities. Activity 9 provides a background on catalysts and is an introduction to the other advanced activities.

The activities in the core deal with the structure and function of the main parts of the digestive system and the rudiments of the mechanical and chemical processes of digestion. The mechanical processes of digestion consisting of the moving and mixing of food by circular and lengthwise muscles, and the increase of surface area by folds in the lining of the stomach and small intestine are also covered. The causes, symptoms, and treatment of a number of unhealthy digestive conditions are studied by playing a game.

The chemical aspects of digestion are dealt with in more detail in the advanced activities. The topics include catalysts in chemical processes; the nature, role, and characteristics of enzymes; and the digestion of starch and proteins. Students investigate how the decomposition of hydrogen peroxide is affected by different cata-

lysts and the effects of temperature, concentration, and pH on the enzyme salivary amlyase.

In the excursion activities, students may investigate some oral conditions that can lead to tooth and gum disease and determine the acidity of their mouths and the amount of plaque on their teeth. They may also compare their digestive system to that of a dissected frog, crayfish, earthworm, or pig.

DIAGNOSIS GAME

Core Activity 6 consists primarily of the game *Diagnosis: Gut Reactions*. The game is supplied separately and consists of "Rules," a "Memory Card," and six "Patient's Cards." In playing the game, pairs of students learn about the causes and symptoms for some digestive conditions and try to diagnose the conditions. It will probably take the students two days to play the game and learn the symptoms and treatments for the different conditions. When they finish the game you may want to remind students that they are not doctors; they only have a better awareness of unhealthy digestive conditions than they had before.

The following chart represents an estimate of needs based on "student units." The student unit may be one student working alone, two students working as partners, or several students working as a group. The size of the student unit will depend on the nature of the activity and on the availability of materials and equipment.

QUANTITY PER STUDENT UNIT	ITEMS	ACTIVITIES			NO. UNITS THAT CAN SHARE
		Core	Advanced	Excursion	
	Consumable				
0.25 ml	*Acetic acid, 5%		10		
10 ml	Biuret reagent		10		
1 slice	*Bread	3			

*Items that can be obtained locally.

Materials and Equipment (continued)

QUANTITY PER STUDENT UNIT	ITEMS	ACTIVITIES			NO. UNITS THAT CAN SHARE
		Core	Advanced	Excursion	
	Consumable				
1 piece	*Cardboard, corrugated 10 cm × 10 cm	5			
1	Crayfish, dissected			14	
100 ml	*Distilled water		10		
1	Earthworm, dissected			14	
2 pieces	*Egg white, cooked		10		
1	Fetal pig, dissected			14	
1	Frog, dissected			14	
50 cm	Glucose-sensitive tape		10		
5 ml	Glucose solution		10		
25 ml	Hydrochloric acid, 0.1 M		10		
15 ml	*Hydrogen peroxide, 3%		9		
5	*Ice cubes		10		
0.5 ml	Lugol's solution		10		
1 piece	Iron Chloride		9		
1 piece	*Liver, raw		9		
	*Lubricating jelly or silicone grease	3			
0.50 ml	*Olive oil		10		
24 cm	pH test paper		10	13	
1	*Plaque-disclosing tablet			13	
5	*Rubber bands		10		
5 ml	Sodium hydroxide solution, 0.1 M		10		
20 ml	*Sodium bicarbonate solution, 1%		10		
100 ml	*Starch suspension, 1%		10		
5 ml	*Sugar, granulated			13	
10 ml	*Toothpaste			13	
1	*Towel, paper	3			
	Nonconsumable				
5	*BBs, copper coated		9		10
1	*Ball, plastic or metal, 7 mm diameter	3			10
3	Beakers, 250-ml		10		10
1	Celsius thermometer		10		10

*Items that can be obtained locally.

Materials and Equipment (continued)

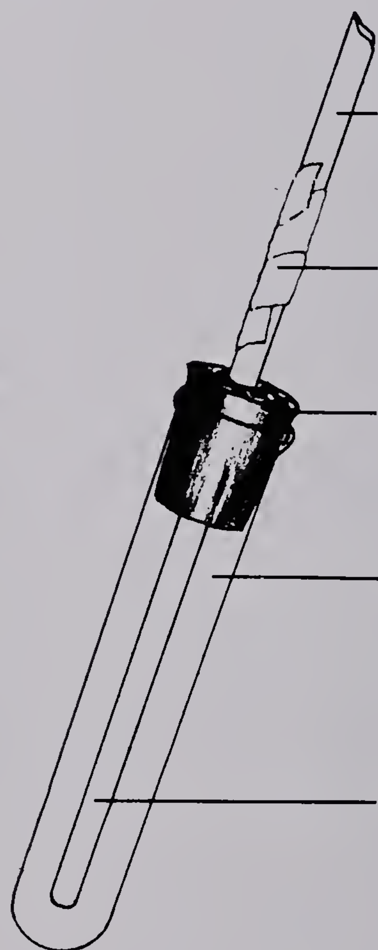
QUANTITY PER STUDENT UNIT	ITEMS	ACTIVITIES			NO. UNITS THAT CAN SHARE
		Core	Advanced	Excursion	
	Nonconsumable				
1	Dissecting probe			14	10
1	Game *Diagnosis: Gut Reactions*	6			10
1	Gas generator		9		10
	*cellophane tape				
	1-hole rubber stopper, #5				
	*2 plastic straws,				
	test tube, 25 × 150 mm				
1	*Grease pencil		10		15
1	Graduated cylinder, 25-ml		9, 10		5
1	*Hand lens			14	10
1	*Metric ruler, 30 cm	5	9		10
1	*Mirror			13	5
1	*Medicine dropper		10		10
1	Pipette, measuring, 5-ml		10		10
1	*Paper clip		9		15
1	*Scissors	5			15
1	*Spoon			13	15
1	Stirring rod		10		10
7	Test tubes, 20 × 150 mm		10		5
1	Test-tube rack		10		10
1	*Timepiece with second hand		10		15
1	*Toothbrush			13	
30 cm	Tubing, flexible rubber, translucent, 6 mm inside diameter	3			10
1	*Resource Unit 4*		9		6
1	*Resource Unit 5*		9		6
1	*Resource Unit 7*		10	13	6
1	*Resource Unit 12*	5			6
1	*Resource Unit 13*	7			6
1	*Resource Unit 18*	7			6

*Items that can be obtained locally.

Activity 9 Advanced Page 36

To assemble the gas generator from the materials listed, refer to the illustration and the directions that follow. Label the setup *Gut Reactions, Activity 9.*

2 plastic straws, clear
cellophane tape
1-hole rubber stopper, #5
test tube, 25 × 150 mm



Push the sharpened end of a pencil into the end of one straw. Slip the second straw into the expanded end of the first. Tape the two straws together. Insert the double straw into the stopper. The straw should fit snugly, but students should be able to adjust it. Push the stopper into the test tube. The stopper should produce a relatively airtight seal with the tube.

To determine what additional materials you want to have for your students to use, look over Step G on page 40. It is not essential to supply all of them.

Several of the solutions required for this activity are available commercially and may be stocked in your school. In any case, directions for all the solutions are included here.

5% acetic acid solution (100 ml): Commerical white distilled vinegar at full strength may be used, or add 5 ml of glacial acetic acid to 95 ml of water and stir well. Dispense this solution from a dropper bottle.

Biuret reagent (about 100 ml): Dissolve 0.5 g of copper sulfate ($CuSO_4 \cdot 5H_2O$) in 200 ml of distilled water to make a 0.01 M solution. Next prepare a 10 M solution of sodium hydroxide by adding 40 g of sodium hydroxide (NaOH) pellets slowly with stirring to 100 ml of distilled water. **Caution:** Use care and pyrex glassware. Add the pellets slowly and stir continuously. The reaction generates a great amount of heat.

Just prior to use, add 2–3 ml of 0.01 M copper sulfate to 100 ml of 10 M sodium hydroxide. Dispense from a dropper bottle.

If you plan to store the 10 M sodium hydroxide, use a cork or rubber stopper in the bottle, or thoroughly grease a glass stopper.

5% glucose solution (200 ml): Dissolve 10 g of glucose (dextrose) in some tap water. Add water to make 200 ml of the solution.

0.1 M hydrochloric acid (500 ml): Put about 400 ml tap water in a labeled container. Add 4 ml concentrated (12 M) hydrochloric acid (HCl). **Caution:** Avoid inhaling concentrated HCl vapors.

Mix thoroughly, then add tap water to make 500 ml of solution.

3% hydrogen peroxide solution: Commercially available hydrogen peroxide is usually about 6%. Mix equal quantities of a 6% solution and tap water to produce a 3% solution. Store in a dark glass bottle in the refrigerator or out of direct sunlight. Screw the cap on tightly, since the solution tends to weaken when exposed to the air.

Lugol's solution (200 ml): Dissolve 3 g of potassium iodide (KI) in 25 ml of distilled water. Add about 0.6 g of iodine crystals and stir until dissolved. Add distilled water to make 200 ml of solution and store in a dark glass bottle. Dispense the solution from a dark dropper bottle.

0.1 M sodium hydroxide (200 ml): Slowly and with stirring, add 1 g of sodium hydroxide (NaOH) pellets to 200 ml of distilled water.

1% sodium bicarbonate (500 ml): Dissolve about 5 g of sodium bicarbonate ($NaHCO_3$) in 500 ml of tap water.

1% starch suspension (1000 ml): This suspension will not keep indefinitely, so prepare it only a day or so before it is to be used.

Add a small amount of cold tap water to 10 g of soluble potato starch and stir into a paste. Then add 1 litre of hot tap water. While stirring constantly bring to a boil. Cool before using. Commercial

liquid laundry starch can also be used. Dissolve 30–40 ml of liquid laundry starch in 1 litre of tap water.

The cooked egg white is prepared by boiling an egg or eggs for five minutes. Separate the whites from the yolks and store the whites in sealed container in a refrigerator.

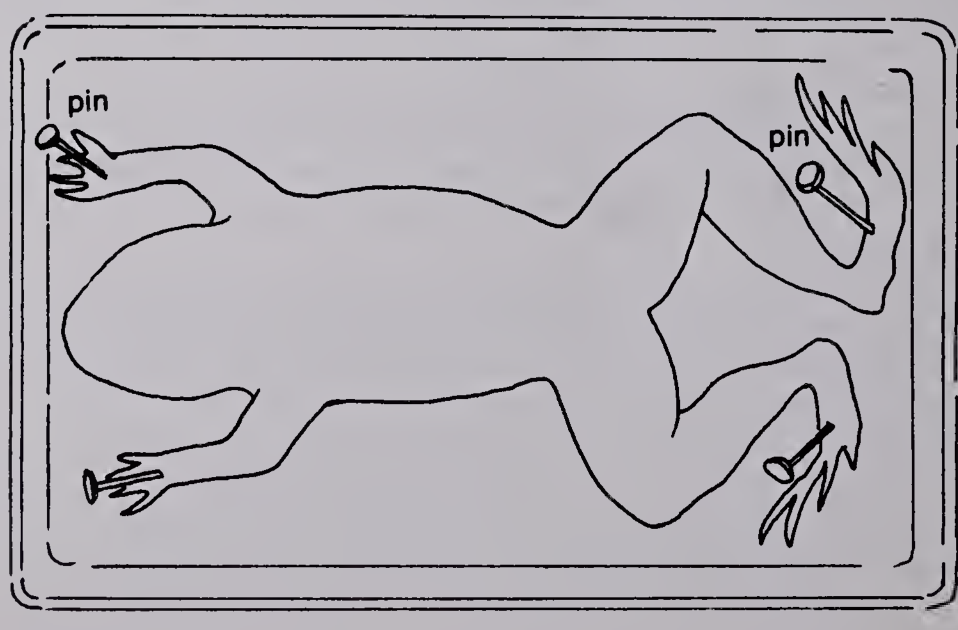
Activity 14 Excursion Page 71

Dissected specimens are required for this activity. You may need to enlist the aid of the biology department in the procurement and dissection of the specimens. Since this is an excursion activity, one set of specimens should be sufficient. If preserved dissections are available, these will probably be adequate.

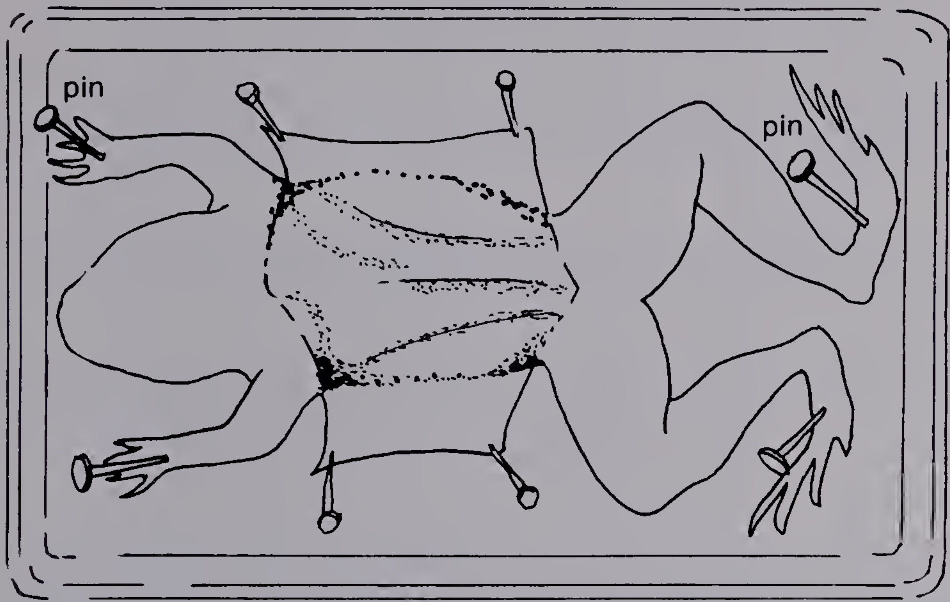
Before dissecting a live frog, kill it by pithing (if you don't know how, don't try) or anesthetizing. To anesthetize a frog to death, soak a wad of cotton in chloroform or ether and put it with the frog into a sealed jar. After the frog is dead, refer to the illustrations and directions to carry out the dissection.

wax dissection pan
8 straight pins
forceps
dissection scissors
blunt probe

Place the frog on its back in the dissection pan. Fasten the frog to the wax in a stretched-out position by pushing pins through the feet.



Pick up the loose skin with forceps. With scissors make a central cut through the skin from near the anus to the region of the throat. Next, cut the skin from the ends of the central cut towards the legs. If necessary, separate the skin from the body wall using a sharp instrument. Pin the skin flaps down.



Now open up the body wall, using the same general procedure as for the skin. Take care—the organs lie just below this wall. The breastbone, between the front legs, may be difficult to cut. Cut only enough to expose the organs beneath it. Pin the body walls to the wax and wash away any blood.

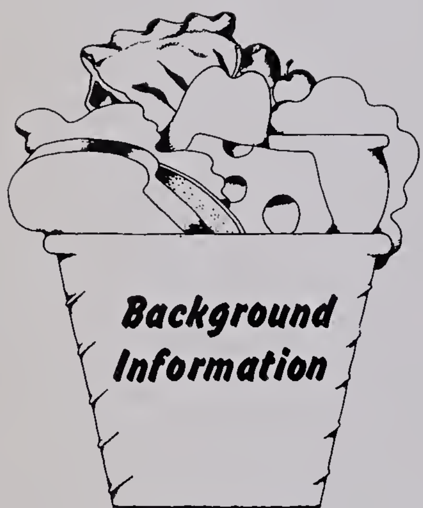
Some frogs will have a cluster of yellowish, fingerlike structures, called *fat-bodies,* attached to the kidneys. These may be cut off for easier viewing.

Follow the same general procedure to do the other dissections. You may wish to use one or more of the references that follow for specific dissection techniques.

Morholt, Evelyn, et al. 1966. *A sourcebook for the biological sciences.* 2nd ed. New York: Harcourt Brace Jovanovich, Inc.

Otto, James H., and Towle, A. 1973. *Biology investigations.* Laboratory manual for *modern biology.* New York: Holt, Rinehart & Winston, Inc.

Weisz, Paul B. 1971. Laboratory manual for *the science of biology.* 4th ed. New York: McGraw-Hill Book Co.

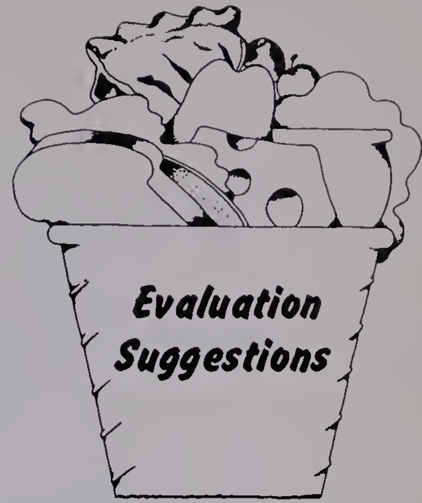


In the adult human being, the digestive tract is about 7.5 to 9 metres long. Food passes through the mouth, pharynx, esophagus, stomach, small intestine, and large intestine in turn. The salivary glands, liver, and pancreas pour their secretions into the digestive tract at various points. The esophagus, or gullet, is a muscular tube that stretches from the pharynx, or throat, to the stomach. It is about 25 centimetres long and 1 to 2.5 centimetres in diameter. The mucous membrane lining of the esophagus has a number of longitudinal folds to allow stretching.

The stomach is an irregularly pear-shaped bag. In front of the stomach is the liver (in part) and behind it are the left kidney and the large intestine. The mucous membrane of the stomach has folds when the stomach is not fully distended. When the stomach is empty it becomes a tubular organ and the transverse colon of the large intestine ascends to occupy the vacant space.

The small intestine is a convoluted tube from 6.5 to 7.5 metres long. The walls are lined by mucous membrane and contain layers of muscle and connective tissue. The mucous membrane has longitudinal folds that also have folds covered with closely packed villi, which greatly increase the surface area.

Where the small intestine and the large intestine are joined is a blind sac called the *caecum.* Attached to the caecum is the notorious wormlike *vermiform appendix,* site of appendicitis. The large intestine is a large, relatively thin-walled tube, ranging in diameter from about 6 centimetres where it leaves the caecum to roughly 3.5 centimetres where it joins the rectum. The length is about 1.5 metres.



In addition to the use of the Minicourse Test, you might want to use some or all of the following suggestions as part of your evaluation.

Essay Questions

Four essay suggestions and their possible answers follow. All are related to core materials, though some will be more suitable for the advanced student.

1. Describe the structure of your stomach walls and explain how this structure aids digestion.

Answer: The muscular stomach walls carry on peristaltic movement and are flexible. They have a corrugated inner surface that provides a large surface area for absorption.

2. Tell where the villi are located and describe two functions that they perform.

Answer: The villi are extremely small, thin-walled fingerlike projections lining the intestine. They increase the surface area for the absorption of food molecules, and contain blood vessels and lymph vessels that transport absorbed molecules to other parts of the body.

3. The human digestive system can't digest the plant carbohydrate, cellulose. How might you get the benefit of the nutrients contained in cellulose?

Answer: Animals such as cattle, sheep, goats, rabbits, and deer live entirely on plants. Their digestive systems have the ability to digest plant cellulose and absorb its nutrients. Thus people could get the nutrients in cellulose by eating the meat or drinking the milk of plant-eating animals.

4. The process of digestion, that is, breaking down food into small particles, begins in the mouth. Explain how.

Answer: Different types of teeth cut, tear, crush, and grind food into small pieces. Food is moistened by saliva as the teeth grind it into small pieces. At the same time a chemical substance in saliva begins to break down starch to simpler substances. The food is mixed and pushed between the teeth by the tongue until the pieces are small enough to swallow.

Biological Sciences Curriculum Study. 1973. *Biological science: an inquiry into life.* 3rd ed. New York: Harcourt Brace Jovanovich.
The enzyme-controlled breakdown of food in humans, as well as other animals, is described in chapter 20. Suitable as a reference for teachers and advanced students.

——. 1973. *High school biology.* 2nd ed. Chicago: Rand McNally & Co.
Chapter 14 has useful information on the digestive organs and various aspects of the digestive process. Some activities might be used as extension material for some students.

——. 1973. *Biological science: molecules to man.* 3rd ed. Boston: Houghton Mifflin Co.
A description of digestion in humans and other animals is included in chapter 22. The thyroid-pituitary feedback system described in chapter 24, as well as material on enzymes in chapter 8, provide useful information for teachers and advanced students. Activities might be used as extension material for some students.

Dubos, René, and Pines, Maya. 1965. *Health and disease.* Life science library. New York: Time-Life Books.
Descriptions of some disorders of the digestive system and a map showing world occurrence are in chapter 1. Ulcers and other reactions to stress by the stomach are included in chapter 7.

Griffith, H. Winter. 1975. *Instructions for patients.* Philadelphia: W. B. Saunders Co.
A collection of instructions for patients. Those on gastrointestinal disorders are suitable for students of all reading levels.

Grollman, Sigmund. 1974. *The human body.* 3rd ed. New York: Macmillan Publishing Co., Inc.
This advanced textbook on human anatomy and physiology is a suitable reference book for teachers.

Haggerty, James J., and Sebrell, William H. 1967. *Food and nutrition.* Life science library. New York: Time-Life Books.
In chapter 4, the pictorial essay "The Human Nutrition Machine" could be useful supplementary reading for all students.

Nourse, A. E. 1964. *The body.* Life science library, New York: Time-Life Books.
Chapter 5 contains a game that would be an interesting remedial exercise for some students.

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GUT REACTIONS

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Acknowledgments

In addition to the major effort by the ISIS permanent staff, writing conference participants, and author-consultants (listed on the inside of the back cover), the following contributed to this minicourse.

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FOREWORD

Evidence has been mounting that something is missing from secondary science teaching. More and more, students are rejecting science courses and turning to subjects that they consider to be more practical or significant. Numerous high school science teachers have concluded that what they are now teaching is appropriate for only a limited number of their students.

As their concern has mounted, many science teachers have tried to find instructional materials that encompass more appropriate content and that allow them to work individually with students who have different needs and talents. For the most part, this search has been frustrating because presently such materials are difficult, if not impossible, to find.

The Individualized Science Instructional System (ISIS) project was organized to produce an alternative for those teachers who are dissatisfied with current secondary science textbooks. Consequently, the content of the ISIS materials is unconventional as is the individualized teaching method that is built into them. In contrast with many current science texts which aim to "cover science," ISIS has tried to be selective and to limit our coverage to the topics that we judge will be most useful to today's students.

Obviously the needs and problems of individual schools and students vary widely. To accommodate the differences, ISIS decided against producing tightly structured, pre-sequenced textbooks. Instead, we are generating short, self-contained modules that cover a wide range of topics. The modules can be clustered into many types of courses, and we hope that teachers and administrators will utilize this flexibility to tailor-make curricula that are responsive to local needs and conditions.

ISIS is a cooperative effort involving many individuals and agencies. More than 75 scientists and educators have helped to generate the materials, and hundreds of teachers and thousands of students have been involved in the project's nationwide testing program. All of the ISIS endeavors have been supported by generous grants from the National Science Foundation. We hope that ISIS users will conclude that these large investments of time, money, and effort have been worthwhile.

Ernest Burkman
ISIS Project
Tallahassee, Florida

CONTENTS

What's It All About?

Wish your stomach wouldn't rumble? Have you ever burped at the wrong time? Choked on a piece of food? Suffered from sharp internal pains? Thrown up or had diarrhea? Ever wonder if you have an ulcer?

Sounds like the start of a TV commercial, doesn't it? That's not surprising. A lot of commercials deal with cures for digestive problems. And if you answered yes to some of those questions, you have probably had some bad "gut reactions."

In this minicourse you'll find out what happens to food as it passes through your body. You'll discover how the food gets broken down, where it goes, and how it is used. You can also play a game to learn more about digestive problems.

core

Activity 1 Planning

If you can't do what is stated in Objective 1 or 2, do Activity 2 first. If you need to do Activity 6, save it for last. Any other activities you need to do may be done in any order, but don't forget to do Activity 4—it's required.

Activity 2 Page 6

Objective 1: On a diagram, identify these parts of the human digestive system: teeth, salivary glands, esophagus, stomach, small intestine, pancreas, liver, gall bladder, large intestine, rectum.

Sample Question: Match the letter of each digestive part with the number of the arrow that points to it in the diagram on the next page.

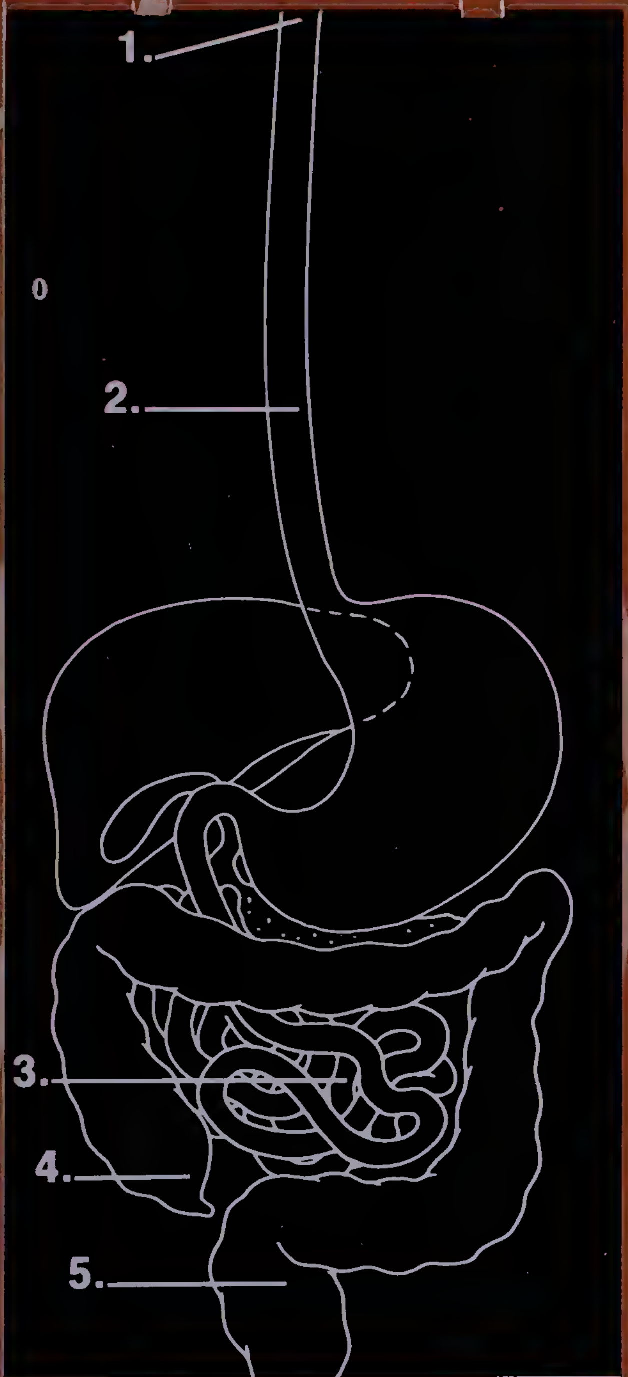
a. esophagus
b. large intestine
c. rectum
d. small intestine

Objective 2: Describe what each of these parts of the digestive system does during digestion: teeth, salivary glands, esophagus, stomach, small intestine, pancreas, liver, gall bladder, large intestine, rectum.

Sample Question: Match each part of the digestive system in List A with what it does in List B.

List A
a. liver
b. gall bladder
c. pancreas
d. rectum

List B
1. stores urine
2. stores bile
3. collects solid wastes
4. produces juices for sugar, fat, and protein digestion
5. makes bile



Activity 3 Page 12

Objective 3: Describe how the digestive parts work when you swallow.

Sample Question: Which of these things happen(s) during swallowing?

a. The mouth is usually closed.
b. The tongue moves down and forward.
c. The air passage to the lungs is closed.
d. The air passage from mouth to nose is closed.

Objective 4: Describe peristalsis and name the digestive parts in which it occurs.

Sample Question: Where and how does peristalsis occur?

a. in the pancreas by the tightening and relaxing of muscles
b. in the esophagus by the pull of gravity
c. in the small intestine by the tightening and relaxing of muscles

Answers
1. a–1 and 2, b–4, c–5, d–3 2. a–5, b–2, c–4, d–3 3. a, c, d. 4. c.

CORE 3

Activity 4 Page 17

REQUIRED ACTIVITY

In this activity, you'll choose your own way to express what you know about your digestive system.

Activity 5 Page 18

Objective 5: Name the two parts of the digestive system that absorb food and tell how their structures help absorption occur.

Sample Question: What are the two parts of the digestive system through which food is absorbed?

Activity 6 Page 24

Objective 6: Describe the causes, symptoms, and treatments of diarrhea, constipation, indigestion, ulcers, and appendicitis.

Sample Question: Which of the following is (are) true?

a. Ulcers seem to run in families.

b. Heartburn is a common symptom of ulcers.

c. Surgery is usually required to treat peptic ulcers.

d. People who smoke cigarettes and drink alcohol are ulcer prone.

Activity 7 Page 25

Objective 7: Describe how hormones regulate the flow of digestive juices.

Sample Question: Which statement is true?

a. A decrease in the amount of thyroxine slows down the pituitary.

b. A decrease in the amount of thyroxine increases the production of TSH.

c. An increase in the amount of thyroxine speeds up the pituitary.

d. An increase in the amount of thyroxine increases the production of TSH.

Objective 8: Tell what happens to every bit of food that enters the body.

Sample Question: Human wastes, or feces, consist mostly of

a. cellulose, extra fats, mucus, and bacteria.

b. proteins, fats, sugars, and water.

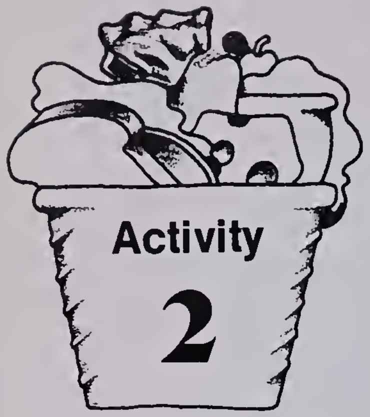
c. cellulose, starch, minerals, and vitamins.

d. bacteria, proteins, starch, and cellulose.

Answers

5. stomach, small intestine

6. a, b, d 7. b 8. a

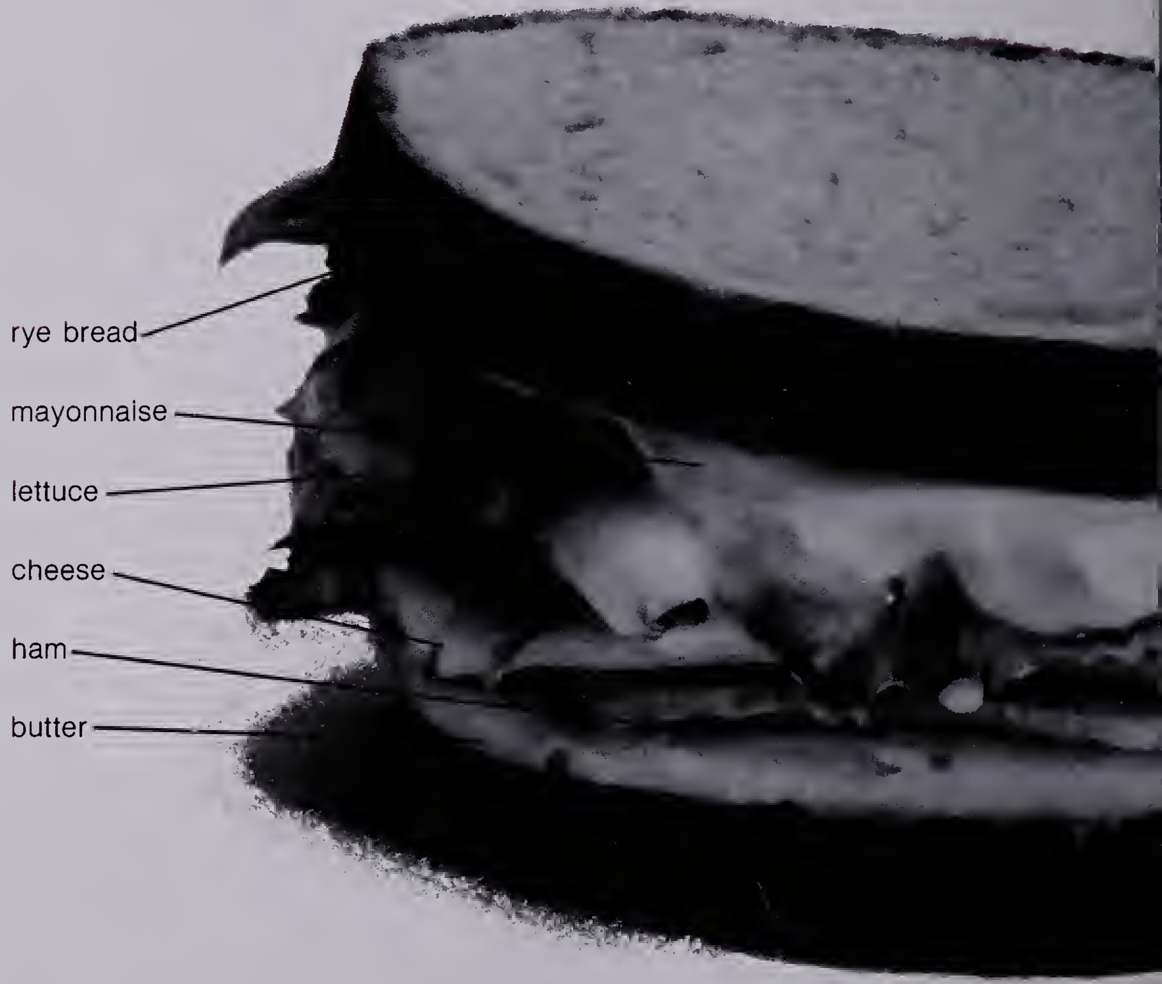


The Adventures of a Sandwich

ACTIVITY EMPHASIS: The parts of the human digestive system and their functions; how the system acts to digest food.

MATERIALS PER STUDENT UNIT
None.

Follow a ham and cheese on rye as it travels through the human digestive system. The different parts of the system do different things to the food.



1. Mouth

The enzyme salivary amylase in saliva breaks down starch. Students can learn more about it in Advanced Activity 10.

Teeth slice, tear, and mash each bite of sandwich into small chunks. Saliva moistens the food. Saliva also breaks down, or *digests,* some of the starch in the bread, changing it into sugar. The tongue pushes the food around and finally back toward the throat. By the time a bite of food is swallowed, it's a moist glob.

2. Esophagus

Sometimes called *gullet.*

Swallowing the food moves it into a tube called the *esophagus* [ee-SOF-a-gus]. The walls of the esophagus move in and out, pushing the food along. The food leaves through a "trapdoor" into the stomach.

3. Stomach

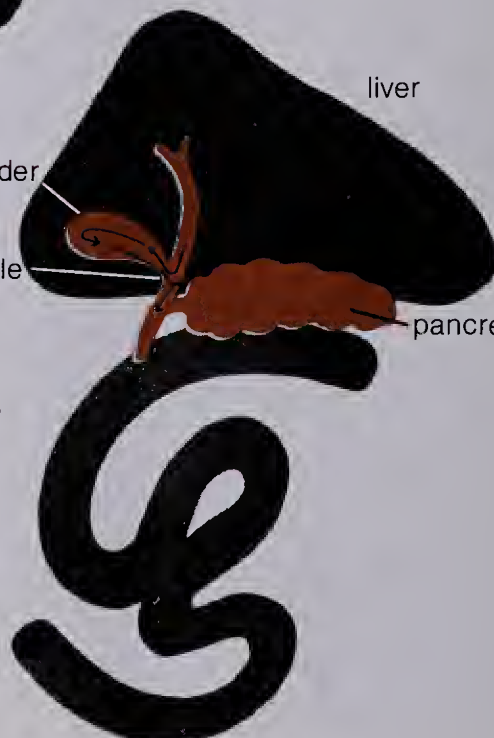
For interested students, Advanced Activity 11 describes the digestion of protein in more detail.

The stomach has rough and ripply walls that churn the food around and mix it with stomach juices. Stomach juices digest some of the protein (from the ham and cheese), but only partway. The juices do almost nothing to the fats (from the butter and mayonnaise). Then the food goes through another trapdoor.

4. Small Intestine

From the stomach, the food enters a tube called the *small intestine.* Now things really start to happen. Digestive juices pour in from all sides.

Digestive juices made by the pancreas [PAN-kree-us] break down sugars, protein parts, and fats.



Bile breaks down large globs of fat into small globs, so digestive enzymes can better digest the fat. Bile is made in the liver and stored in the gall bladder until needed.

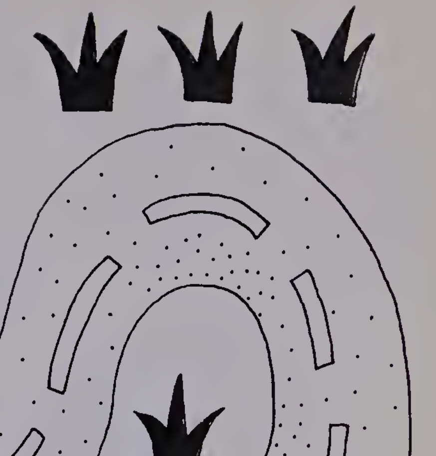
Other digestive juices come right from the intestinal lining.

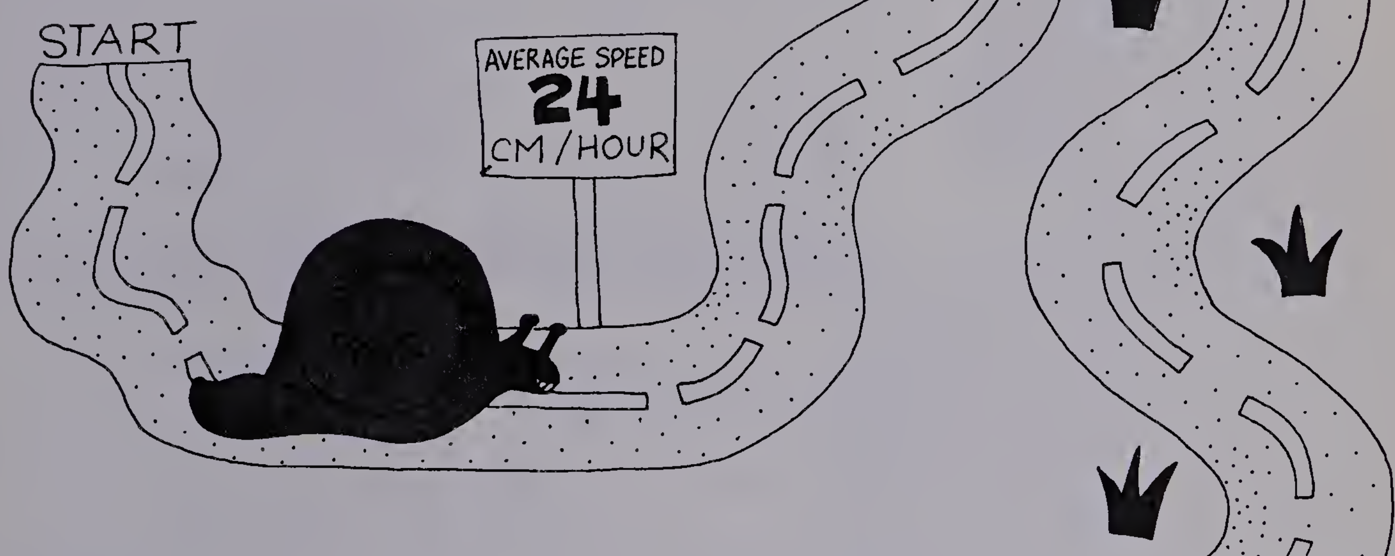
A description of villi and the absorption of food are included in Activity 5.

Like the walls of the esophagus, the walls of the small intestine move in and out. And like the stomach walls, the intestinal walls have big folds. But the intestinal folds are also covered with tiny, waving "fingers." These fingers soak up, or *absorb,* the digested substances; they give the broken-down food a passageway into the bloodstream. The food parts that aren't broken down, such as plant fibers from the lettuce, keep on moving through.

5. Large Intestine

The small intestine enlarges to become the large intestine. It too has ripply, moving walls but no "fingers." Here, the walls squeeze the undigested materials as well as push them. No digestion takes place, but water and minerals are absorbed through the intestinal walls into the bloodstream.

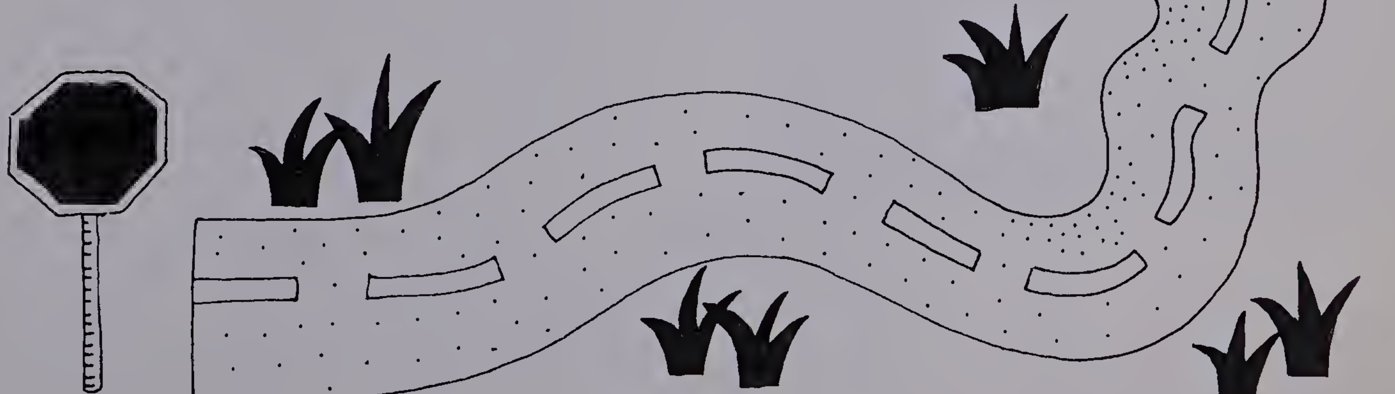




6. Rectum

At the end of the large intestine, the rectum serves as a waiting room for the food's "leftovers." At fairly regular intervals, the body gets rid of its waste through an exit, the *anus*.

Altogether, that ham and cheese sandwich took about one and a half days to travel only 8.75 metres—a very slow pace of about 24 centimetres an hour!



★ **2-1. Match each part of your digestive system with the statement that tells about it.**

a. Esophagus	**1. Makes juices that break down sugars, fats, and proteins.**
b. Gall bladder	**2. Long muscular tube that goes from mouth to stomach.**
c. Large intestine	**3. Moistens food and breaks down starches in mouth.**
d. Liver	**4. Food and juices are churned here.**
e. Pancreas	**5. Water and minerals go through its walls.**
f. Rectum	**6. Makes bile.**
g. Saliva	**7. Cut, tear, crush, and grind food.**
h. Small intestine	**8. Wastes are collected here.**
i. Stomach	**9. Stores bile.**
j. Teeth	**10. Most digestion occurs here.**

2-1. a-2, b-9, c-5, d-6, e-1, f-8, g-3, h-10, i-4, j-7

If you had no trouble with Question 2–1, go on to the next activity you want to do. But if you had trouble, read about Professor Hodge-Podge's design and answer Question 2–2.

PROFESSOR HODGE-PODGE'S DESIGN

Professor Hodge-Podge has designed a new digestive system and plans to try it out in an artificial human. His plan is shown in Figure 2–1, where he has described what will happen in ten parts of the system. Examine the professor's diagram.

1. Food is broken into small dry pieces in the mouth.
   Dry pieces will not slide easily in the esophagus.
2. Digestion begins in the esophagus. Food passes quickly through the esophagus, so there is little time for digestion.
3. Some food passes through the walls of the stomach, but nothing else happens here.
4. Juices from the pancreas are used in the stomach.
   Juices enter the small intestine.
5. Food moves through the small intestine by gravity.
   Food will collect in low places and block food transport.
6. Food particles pass through pin-sized holes in the small intestine.
   Liquids and digestive juices will also pass through.
7. The small intestine has smooth walls.
   Food transportation will be difficult.
8. Bile enters the large intestine.
   Fats will be digested after they can be absorbed.
9. Materials collected in the large intestine supply nutrients between meals.
10. Kidneys collect all wastes that are eliminated from the body.

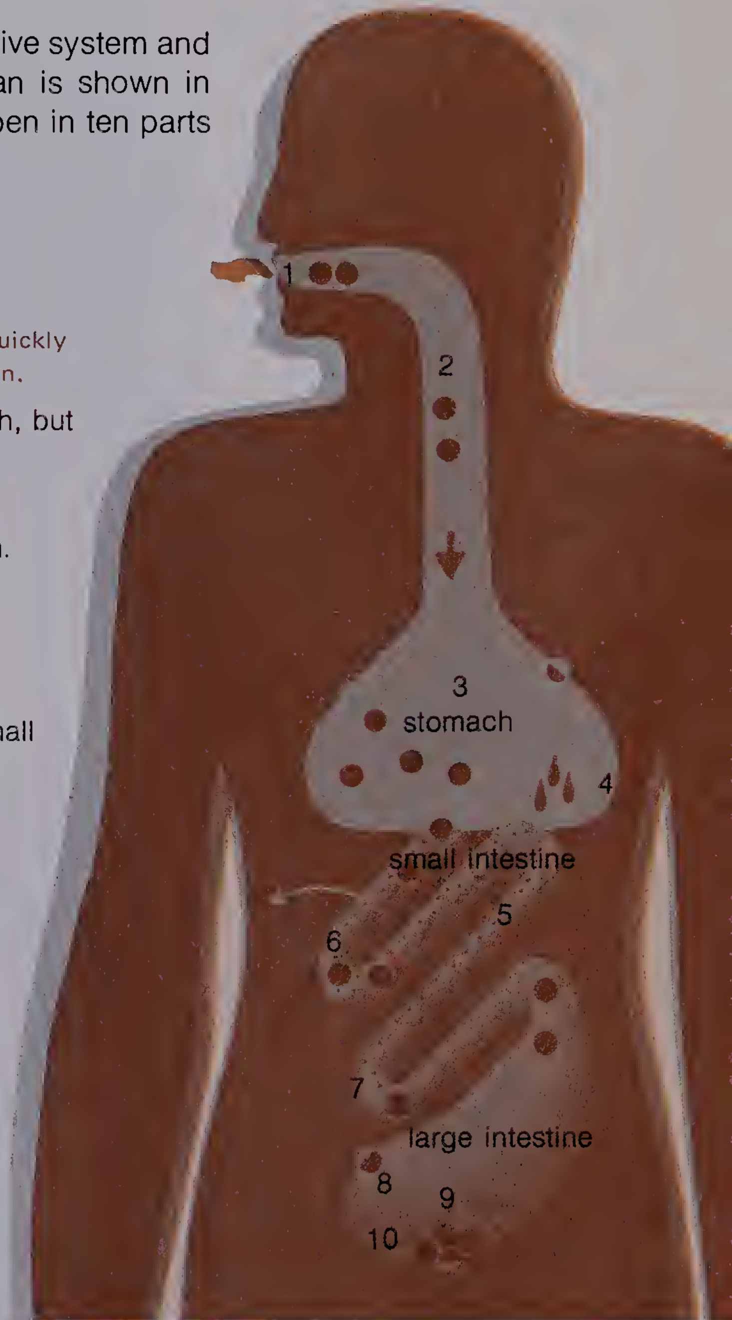
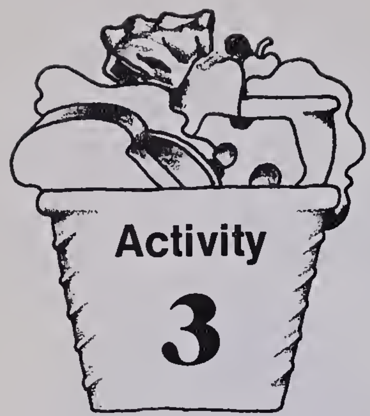


Figure 2–1

✔ 2–2. List any problems you see in the professor's diagram. Then make your own diagram to improve on Professor Hodge-Podge's. Number the parts on your diagram and describe each part and its function.

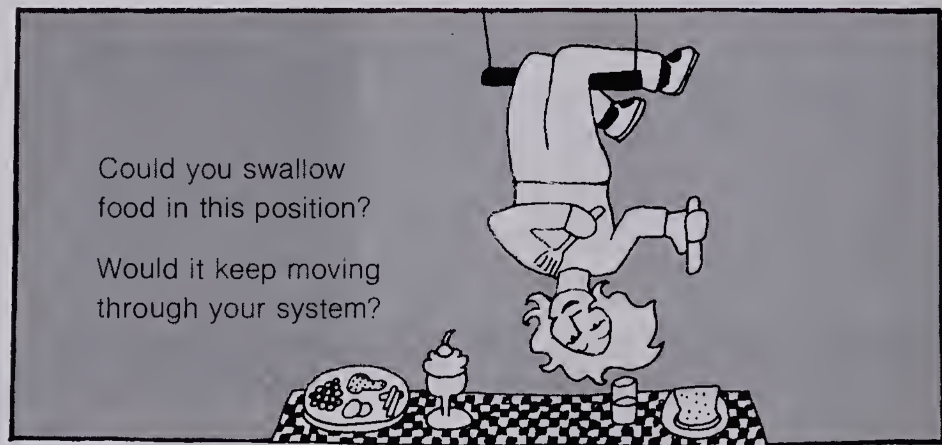
2-2. See comments on Figure 2-1. Diagrams should show how students solve the problems they listed. Diagrams may be similar to the one on p. 7.



Down the Tube

ACTIVITY EMPHASIS: Circular and length-wise muscles produce a rhythmic motion that mixes and moves food. Students investigate how they swallow.

How do you swallow? Get a piece of bread and chew some of it. Swallow slowly and try to feel what is happening in your mouth and throat.

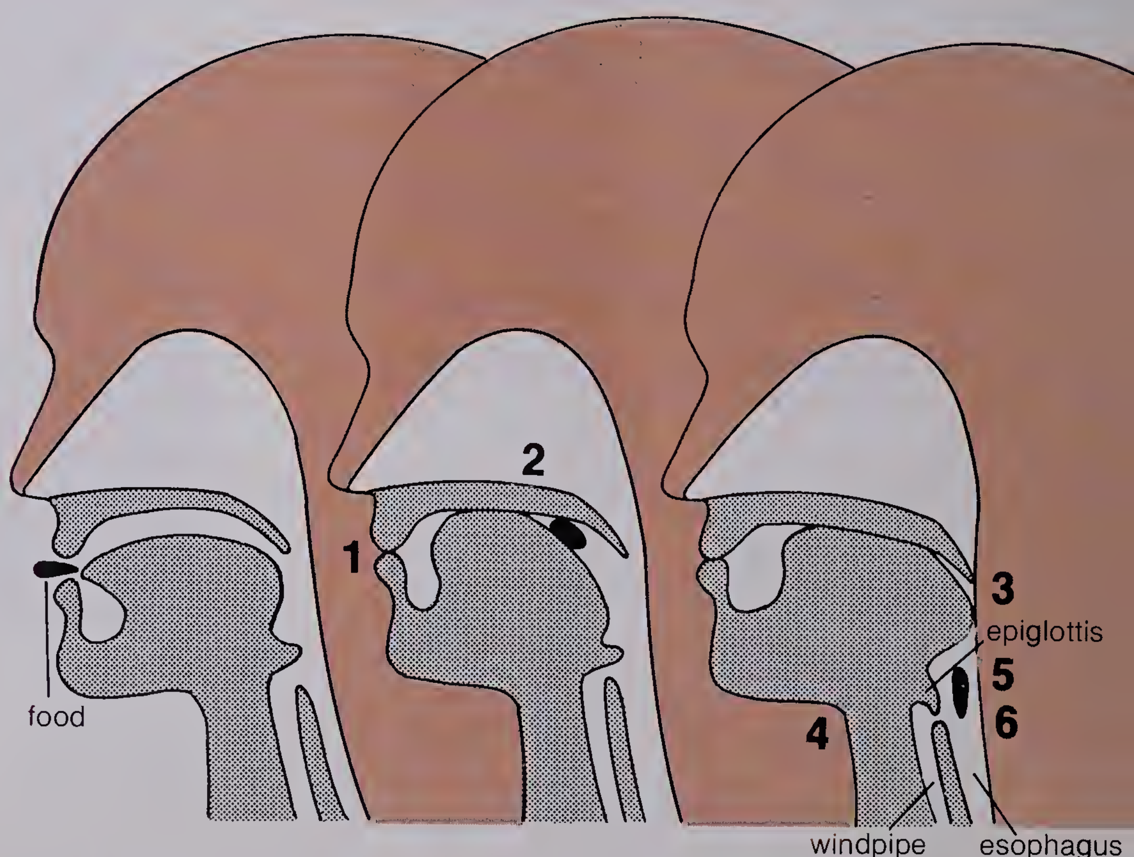


MATERIALS PER STUDENT UNIT
bread, 1 slice
lubricating jelly or silicone grease
paper towel
plastic or metal ball, 7 mm diameter
30 cm flexible tubing, 6 mm inside diameter

Swallow another piece of bread as you think about each thing that happens. If you hold your hand on your throat, you'll feel the movement of your voice box.

Were you aware that all this happened?

1. Your lips closed.
2. The back of your tongue moved up and back, pushing the food down your throat.
3. At the back of your mouth, the opening to your nose closed.
4. Your voice box moved up.
5. The opening to your windpipe was covered by the epiglottis.
6. The food went into your esophagus.



★ **3–1. What body part pushes food from the mouth to the esophagus?**

3-1. Tongue.

★ **3–2. What body parts in your mouth and throat move during swallowing?**

3-2 Lips, tongue, voice box, epiglottis, and the opening to the nose.

Once food is pushed into the esophagus, it might seem that gravity alone could pull it through from there. But if that were true, how could food continue to move through your body when you're lying down? Or standing on your head?

It takes muscle power. There are two kinds of muscle in your esophagus, stomach, and intestines. One kind of muscle wraps around in a circular direction. The other kind runs up and down, or lengthwise. You can see the two kinds of muscle in Figure 3–1.

Figure 3–1

The circular and lengthwise muscles take turns tightening and relaxing. In this way, they squeeze food through the system. (See Figure 3–2.) It's like pushing toothpaste out of a tube.

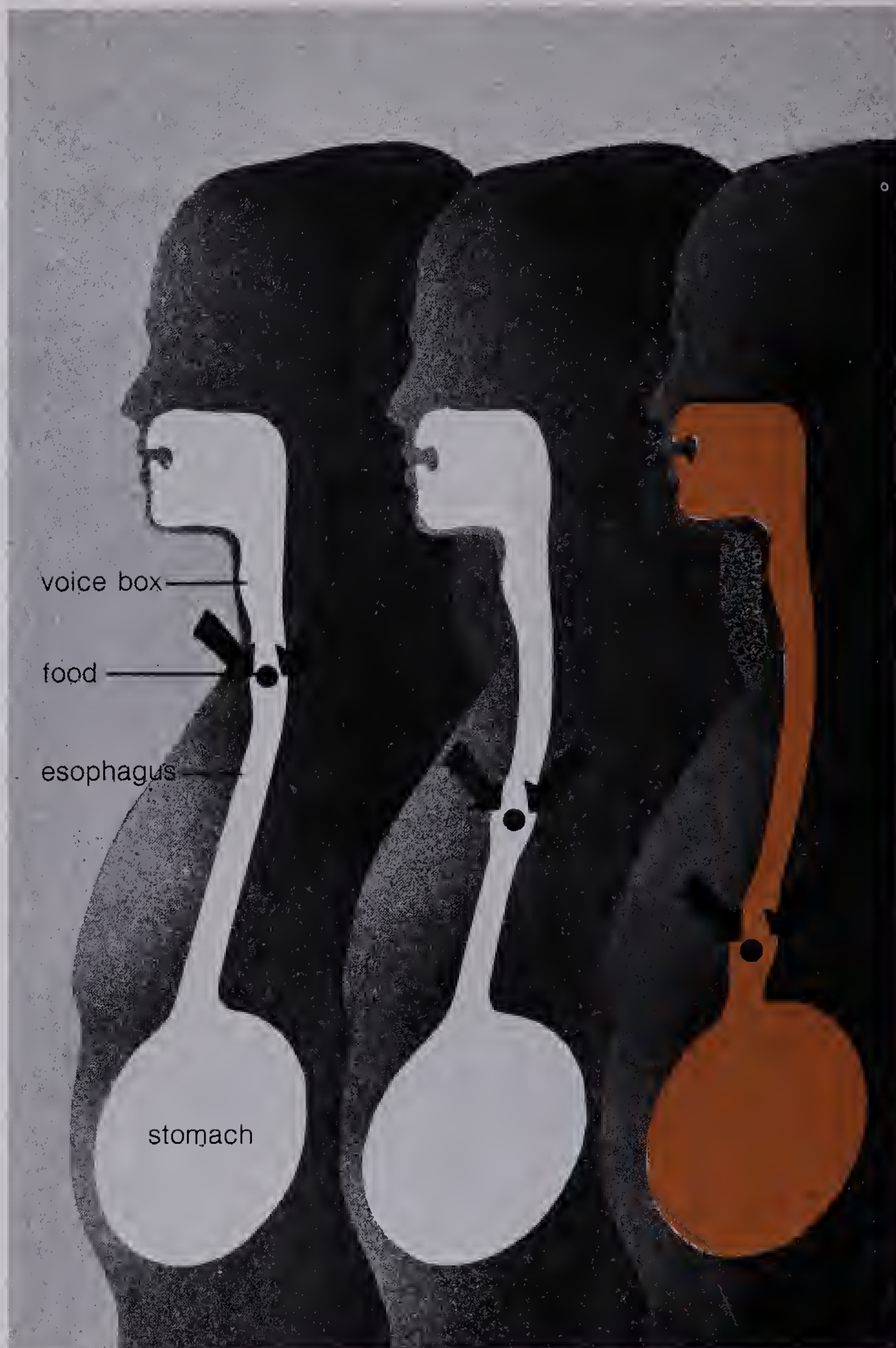


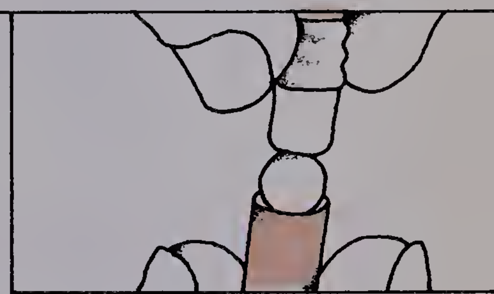
Figure 3–2

See for yourself how food is moved through your esophagus, stomach, and intestines. You will need the following items:

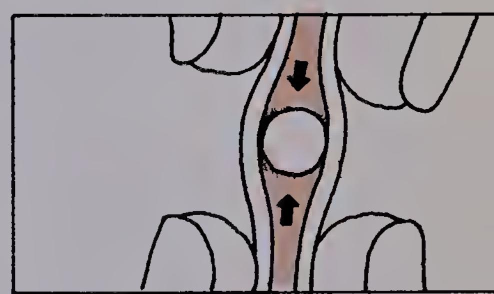
lubricating jelly or silicone grease
paper towels
plastic or metal ball, 7 mm in diameter
30 cm flexible rubber tubing, 6 mm in diameter

A. Put a dab of jelly on a paper towel. Roll the plastic or metal ball in the jelly until the ball is covered with it.

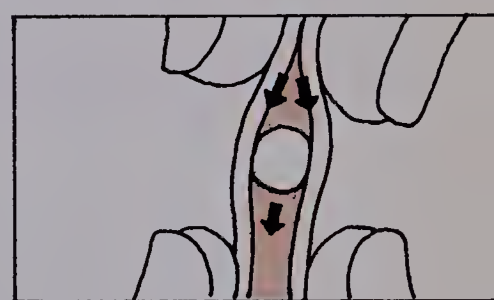
B. Insert the ball into one end of the rubber tube. Use a pencil to push the ball in as far as possible. Wipe any jelly off your hands and the outer tubing with a paper towel.



C. With the thumb and index finger of one hand, squeeze the tube just above the ball. With the thumb and index finger of the other hand, squeeze the tube about 2 cm below the ball.



D. Push both hands toward the ball, then release the hand below the ball, still squeezing at the top. After the ball moves, relax the hand above the ball. Continue to squeeze, push, and release until the ball comes out the other end of the tube.



The pushing and squeezing motions of your fingers are like the actions of the two kinds of muscle in your esophagus, stomach, and intestines.

3-3. Lengthwise; circular.

✓ 3–3. Which kind of muscle were you imitating when you pushed the tubing toward the ball? Which kind when you squeezed the tubing?

3-4. A piece of food.

✓ 3–4. What did the ball in the tubing model represent?

The two kinds of muscle produce a rhythmic motion in your esophagus, stomach, and intestines. The motion is called *peristalsis* [per-i-STALL-sis]. In your stomach, it mainly churns the food around. In your esophagus and intestines, it mainly moves the food ahead.

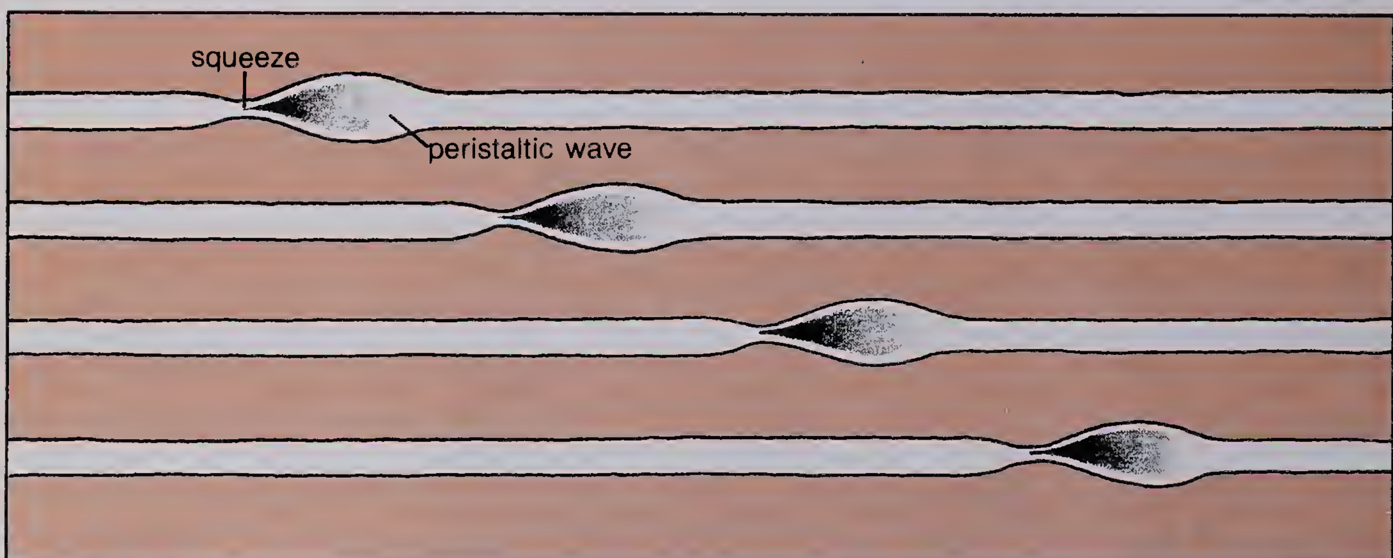


Figure 3–3

3-5. They rhythmically push and squeeze food forward.

★ **3–5. What do muscles do to move food through the digestive system?**

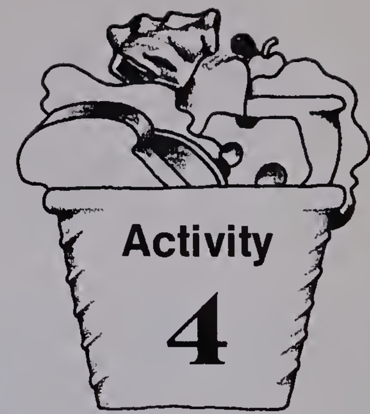
3-6. Food would return to the mouth.

✓ 3–6. Suppose the tightening waves in your esophagus suddenly started moving up instead of down. What would happen?

3-7. Intestines, esophagus, and stomach.

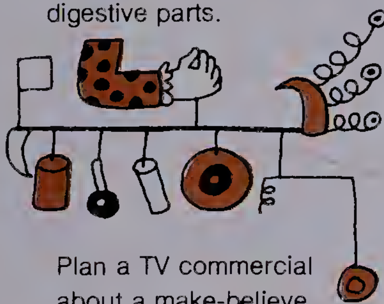
★ **3–7. Name three body parts in which peristalsis occurs.**

Express Yourself

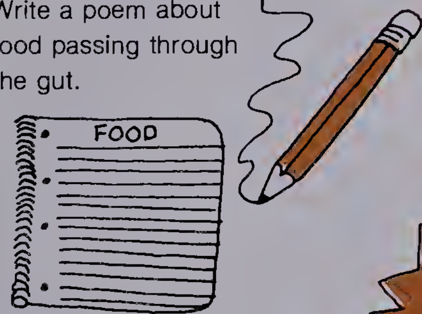


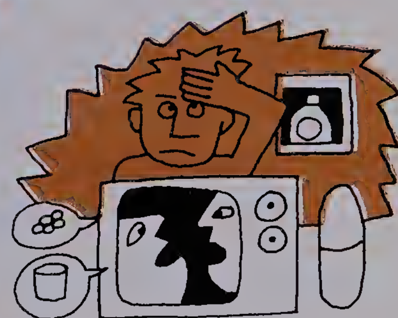
In this activity, you'll choose your own way to describe "gut reactions." You may focus on only certain parts of the digestive system, or you may try to express how they all work together. You'll find some suggestions with the pictures on this page.

Make a mobile of objects or pictures that show real things in your environment (home, school, store, etc.) that do the same sort of work as your digestive parts.



Write a poem about food passing through the gut.

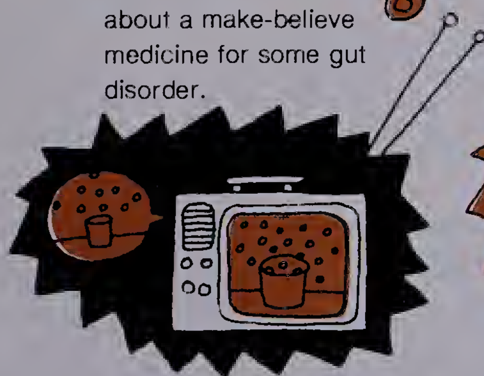




What kinds of disorders are most often advertised on TV or in the printed media? How are the products the same or different in their effectiveness?

Make a collage of objects or pictures that express the various ways the digestive parts work.

Plan a TV commercial about a make-believe medicine for some gut disorder.

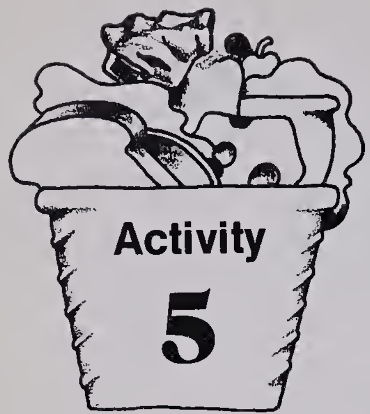


Whatever method you choose, your final product should include one or more of the following ideas:

Feedback in the digestive system
How things are moved through the gut
The breakdown and absorption of foods in the gut
The elimination of waste materials
Gut disorders

The form of expression is up to you. You may want to join talents with a friend for a combined effort. Hand in your finished product to your teacher.

MATERIALS PER STUDENT UNIT
None.



Like a Sponge

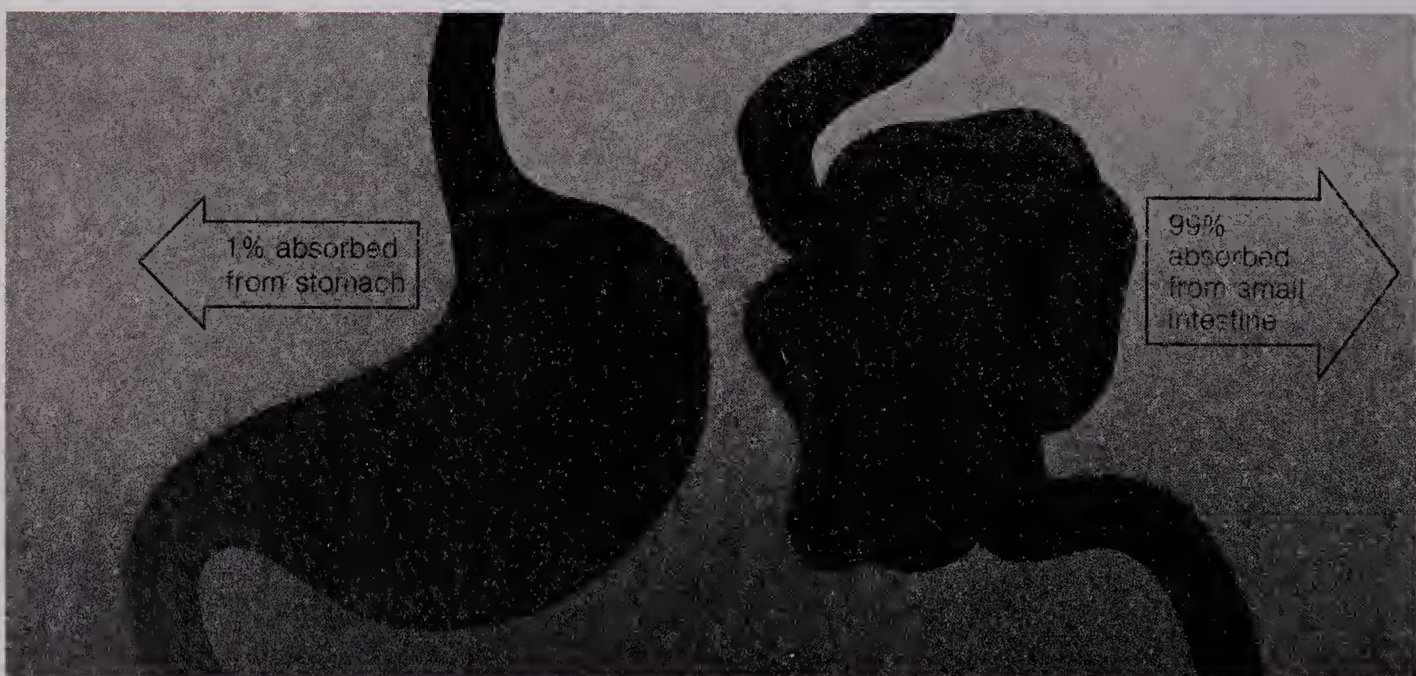
ACTIVITY EMPHASIS: Digestion and absorption take place in the stomach and small intestine. Students investigate how folds increase surface area.

Your stomach is a marvelous thing. It stretches to hold all the food and drink you send down. If the stomach didn't stretch, you would eat a lot less at each meal, but you'd have to eat many more meals.

MATERIALS PER STUDENT UNIT
scissors
metric ruler
notebook paper
corrugated cardboard, 10 cm x 10 cm
Resource Unit 12

Protein molecules are broken into simpler molecules that are still too large to be absorbed.

The stomach sloshes and churns food into a thin paste. Some food is partly digested here, but very little food is absorbed through the stomach walls into the bloodstream.



Most digestion and absorption take place in the small intestine. How does the small intestine do this? And how can your stomach hold all the snacks you eat on top of meals?

Both the saclike stomach and the tubelike small intestine have walls with closely packed folds (Figure 5–1). The folds play an important part in the movement, mixing, and absorption that occur in the stomach and small intestine.

Figure 5–1

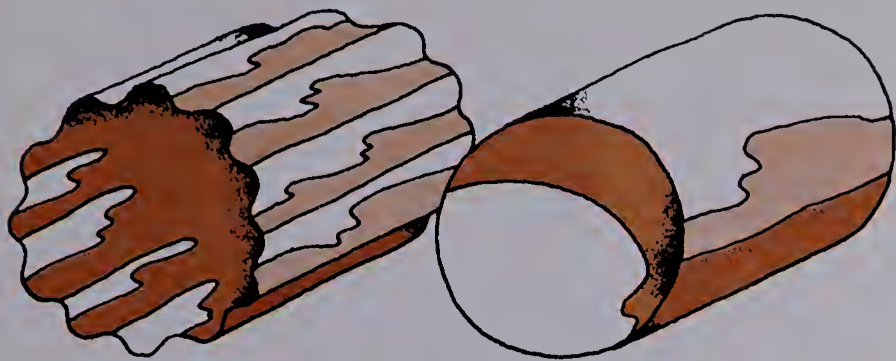
Such folds increase the *surface area* of the gut—the amount of gut that food can come in contact with. To see this, you'll need:

scissors
metric ruler
notebook paper
corrugated cardboard, 10 cm × 10 cm
container of water

A. Cut the notebook paper into a piece 10 cm × 10 cm. Place the paper on top of the piece of cardboard to check that they are the same size. Set the piece of notebook paper aside.

B. Carefully remove the paper covering from *both* sides of the corrugated cardboard. Sliding a sharp pencil along the grooves will help to break away the paper.

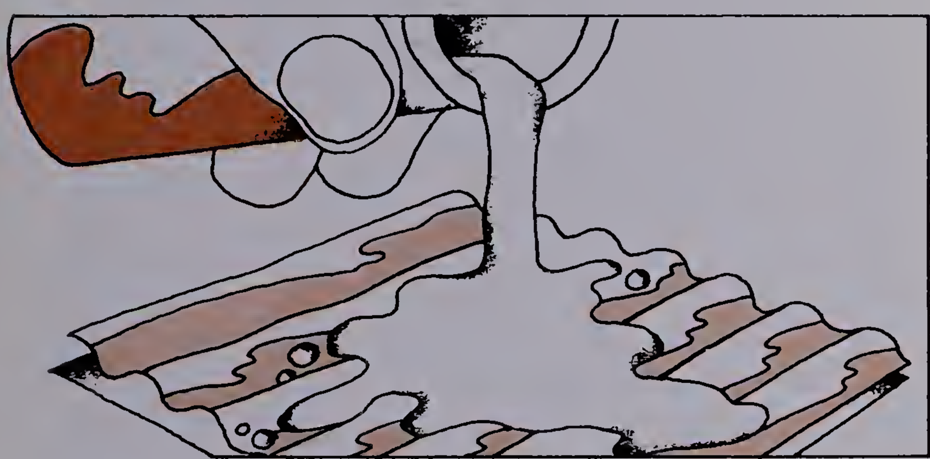
C. Roll the piece of notebook paper and the cardboard into tubes. The tubes should be the same size.



5–1. Look at the two tubes. What do you think are some advantages of a corrugated wall over a smooth wall?

5-1. Answers will vary, but could include expanding to store more food and providing more surface.

D. Wet the piece of cardboard and flatten it out on a tabletop. Compare its size with the piece of notebook paper.



5–2. Which wall, the corrugated or smooth, has the greater surface area?

5-2. Corrugated.

The surface area of the gut is increased by the folds. This means that more surface is exposed to food as it passes through the stomach and small intestine. This in turn aids digestion in the stomach and digestion and absorption in the small intestine.

★ **5–3. Suppose the small intestine had smooth walls instead of folds. How would this affect the way food moved through the intestine? Explain your answer.**

5-3. Food and digestive juices would not be mixed as well, since folds help mix and move food.

★ **5–4. How would a smooth-walled small intestine affect absorption? Explain your answer.**

5-4. Less food would be absorbed, because there would be less surface area.

The folds in the small intestine are more complicated than those in the stomach. In the small intestine, the folds are covered with small fingerlike projections called *villi* (Figure 5–2). The motion of the folds and villi helps move food.

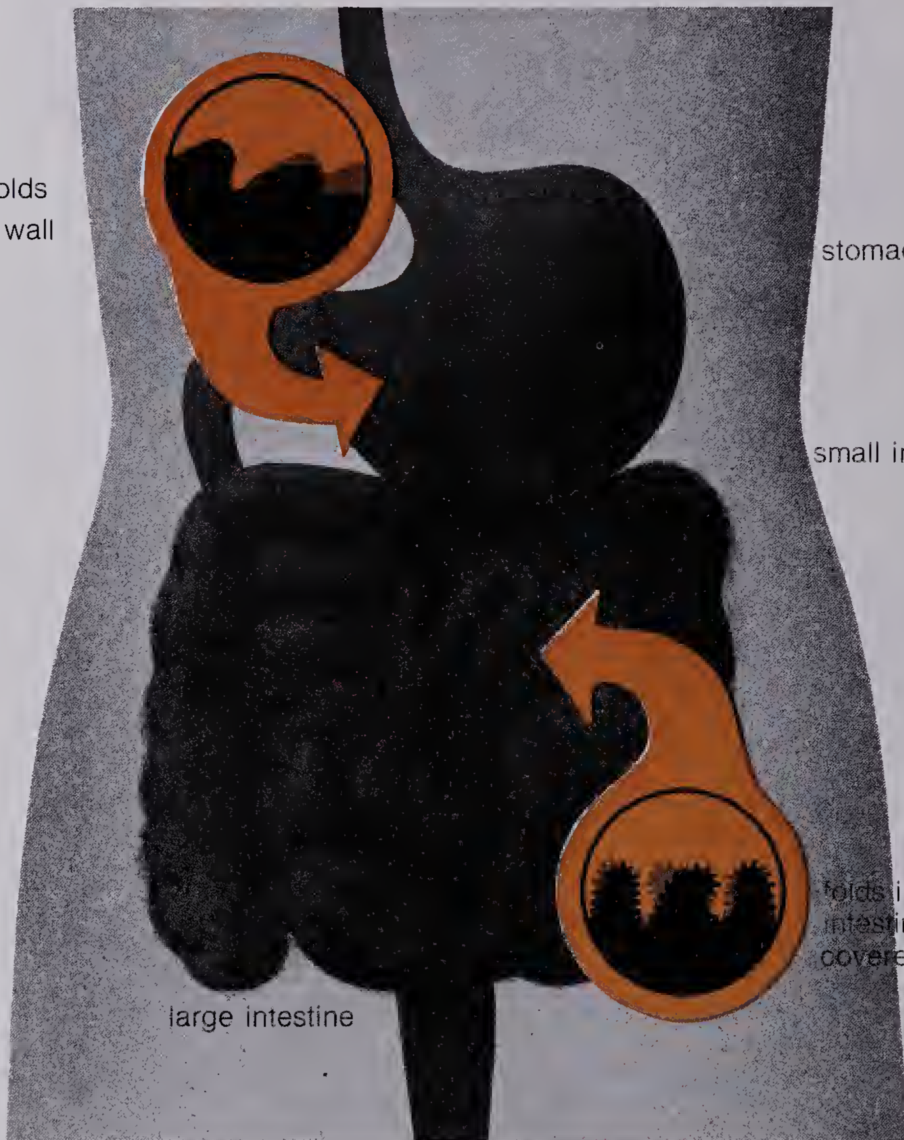
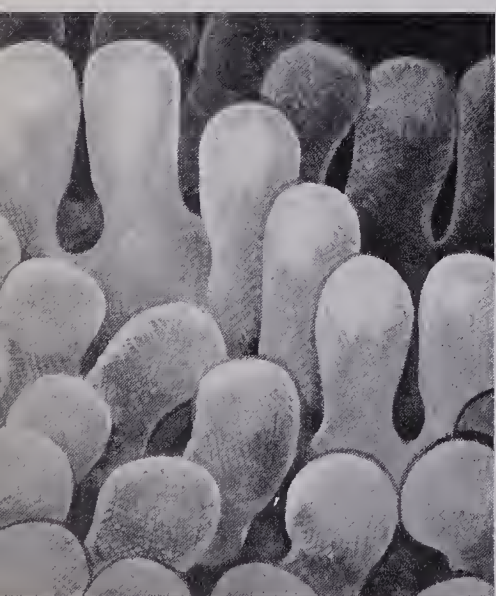


Figure 5–2



Villi are about the size of the commas on this page. They make the lining of the small intestine look like a bath towel with fuzz that is always moving. Because of the villi, the surface area of the small intestine is about the size of a basketball court. That's a lot of surface!

The villi soak up digested food like a sponge soaks up water. The cross section of villi in Figure 5–3 shows that they are rich in blood vessels. The digested food, once absorbed, enters the blood system and is carried to all parts of the body.

Figure 5–3

★ **5–5. How would fewer villi in the small intestine affect absorption?** 5-5. Less food would be absorbed.

Just how do the villi absorb the food? This is not well understood, but there seem to be two ways. One way requires energy and the other way does not. Most sugar particles from food cannot pass through the walls without effort, but have to be "pulled" through. The process is not easily explained; the important thing is that it takes energy to absorb sugar particles.

Fat particles, on the other hand, can go through villi walls with no effort at all. They simply move from a place where there are a lot of fat particles to a place where there are fewer fat particles. This is an example of *diffusion*. It's like opening up an orange and having someone across the room smell it.

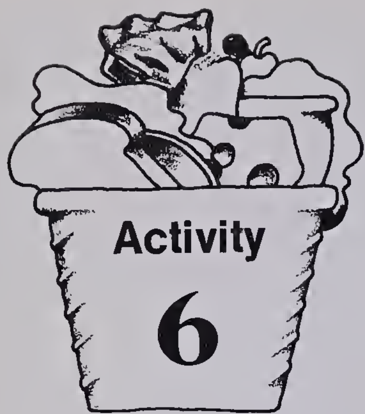
If you're not sure about the answer to any of the next three questions (Question 5–6, 5–7, or 5–8), do *Resource Unit 12.*
Have *Resource Unit 12* available to aid students in understanding diffusion.

★ **5–6. What is meant by the word "diffusion"?** 5-6. Movement of particles of gases, liquids, or solids from a higher to lower concentration.

★ **5–7. How does the size of food particles affect their passing through a wall or membrane?** 5-7. Particles must be a certain size or smaller to pass through a particular membrane.

★ **5–8. How does the concentration of particles on each side of a wall or membrane affect diffusion?** 5-8. The more concentrated the particles, the more and the faster they will move.

★ **5–9. Name the part of the gut where most digested food is absorbed.** 5-9. Small intestine.

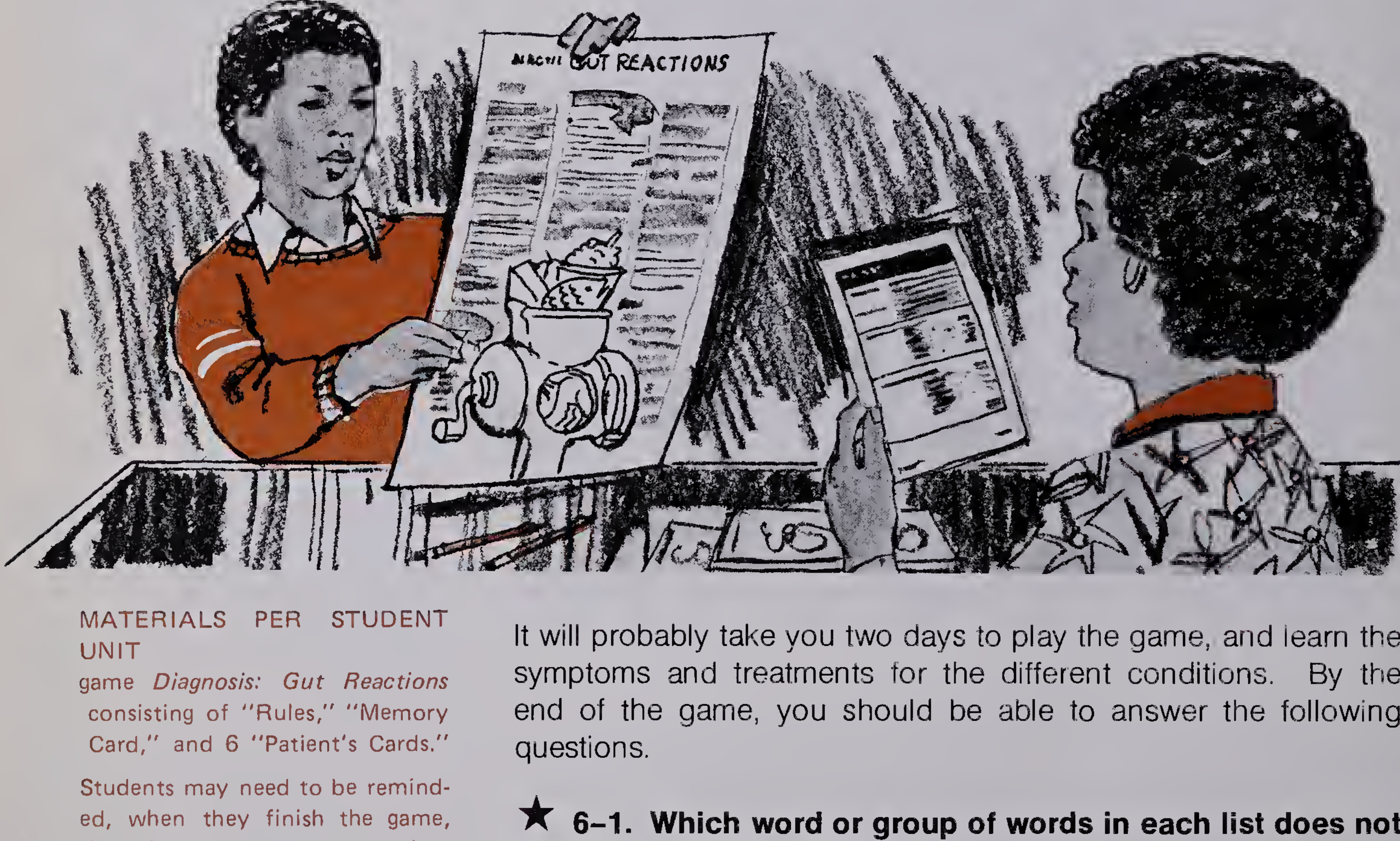


I Don't Feel Too Good, Doc

ACTIVITY EMPHASIS: Students use the game *Diagnosis* to investigate the causes, symptoms, and treatments for various digestive problems.

This activity includes a game in which you and a partner learn about patients' symptoms and try to diagnose what may be causing the problems. The "doctor" who better diagnoses and "treats" the conditions during the game will be the winner. You will need the following materials:

- a partner
- game *Diagnosis: Gut Reactions,* consisting of "Rules," "Memory Card," and 6 "Patient's Cards"
- blank paper for keeping score



MATERIALS PER STUDENT UNIT
game *Diagnosis: Gut Reactions* consisting of "Rules," "Memory Card," and 6 "Patient's Cards."

Students may need to be reminded, when they finish the game, that they are not doctors; they only have a better awareness of unhealthy digestive conditions than they had before.

6-1. a. Rectum.
b. Pain in lower right abdomen.
c. Jaundice.

It will probably take you two days to play the game, and learn the symptoms and treatments for the different conditions. By the end of the game, you should be able to answer the following questions.

★ 6–1. Which word or group of words in each list does not belong with the other four?

a. Laxative, diarrhea, enema, rectum, constipation

b. Gas pains, antacids help, sharp pain in lower right abdomen, eat slower, heartburn

c. Jaundice, dehydration, emotional upsets, anti-diarrheal agent, loose and watery bowel movements

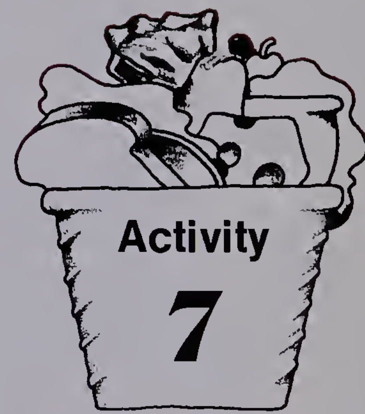
★ **6–2. Name one major cause, symptom, and treatment for acute appendicitis.**

6-2. Cause: decreased supply of blood or blockage. Symptom: lower right abdomen tender. Treatment: Surgery.

✓ 6–3. Mary Claire and Tim spent the evening eating pizza, dancing, and generally having a great time. The next morning they each woke up with a bloated feeling, heartburn, and gas pains. What's wrong with Mary Claire and Tim? What should they do to relieve their symptoms?

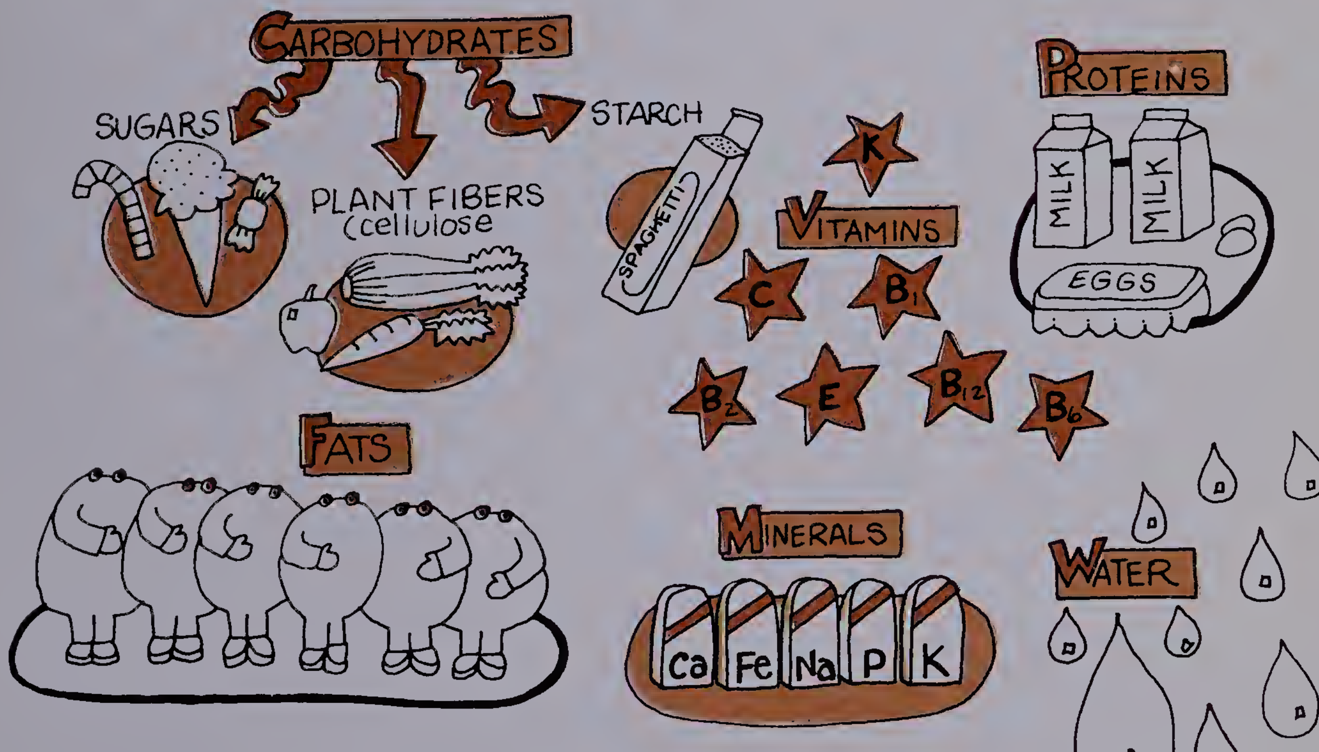
6-3. Indigestion: Take an antacid.

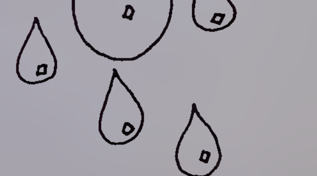
Cheeseburger, Cola, and Fries, Please



ACTIVITY EMPHASIS: Metabolic activities in the body are regulated by hormones. All food eaten is either absorbed into the body or eliminated.

Have you ever ordered that meal? One hamburger chain boasts that it has sold billions of such meals. You might even be one of its customers. Whatever you eat, most meals consist of six main nutrients.





Believe it or not, your everyday cheeseburger offers all six nutrients. Figure 7–1 shows where they're found. If you're like a lot of people and add cola and fries to your order, you'll get some nutrients (fats and carbohydrates) in excess.

MATERIALS PER STUDENT UNIT
Resource Unit 13
Resource Unit 18

WHAT'S IN A CHEESEBURGER?

PARTS	WATER	CARBOHYDRATES	FATS	PROTEINS	MINERALS	VITAMINS
Bun	★	★ (starch)	✓	✓	✓	✓
Hamburger	★		★	★	✓	✓
Cheese	★	✓	★	★	✓	✓
Salt					✓	
Butter	★	✓	★	✓	✓	✓
Tomato	★	✓ (cellulose)	✓	✓	✓	✓
Lettuce	★	✓ (cellulose)	✓	✓	✓	✓

★ Principal nutrients
✓ Nutrients present in small amounts

Figure 7–1

✔ 7-1. From what part or parts of a cheeseburger do you get the most proteins? Carbohydrates? Fats?

7-1. Hamburger and cheese; bun; hamburger, cheese, and butter.

How does your body handle all these materials? Some it can't handle at all, like the plant carbohydrate *cellulose* [SELL-ya-loas]. The body simply eliminates the materials it can't use. But the materials it can use, it uses well. (The body may even use some nutrients to excess, such as fat.)

The body's digestive system first breaks usable materials into simpler forms. These simple materials are then absorbed into the bloodstream and carried to all of the body's cells. The body cells do one or two things with the simple materials.

Some food parts are used to build materials to keep the body in "good working order."

Some food parts are broken down even more to produce energy.

wastes

This process of breakdown and buildup is called *metabolism* [ma-TAB-a-liz-um]. Metabolism is an around-the-clock job for the body. If metabolism ever decided to take a day off, the body would be "out of business."

✔ 7-2. Describe the two main functions of metabolism.

7-2. Provide the body with energy and food parts to build materials.

Think for a minute about working 24 hours a day *every day.* As you can imagine, you'd need a good reason to keep going, or a mighty tough boss. The "bosses" of metabolism are special groups of cells that release chemical substances into the bloodstream. The groups of cells are *glands* and the chemical substances are *hormones.*

Glands and their hormones affect many bodily activities, but certain glands zero in on metabolism. You have a gland in your throat called the *thyroid*. The principal hormone released by the thyroid gland is thyroxine. Directly or indirectly, thyroxine helps to control most of the metabolic activities in your body. Figure 7–2 shows only six of those activities.

And who bosses the thyroid? Some gland has to make sure that the thyroid doesn't get carried away and run things too fast, or get lazy and let things go. That controlling gland is the *pituitary*, and it releases thyroid-stimulating hormone, or TSH for short.

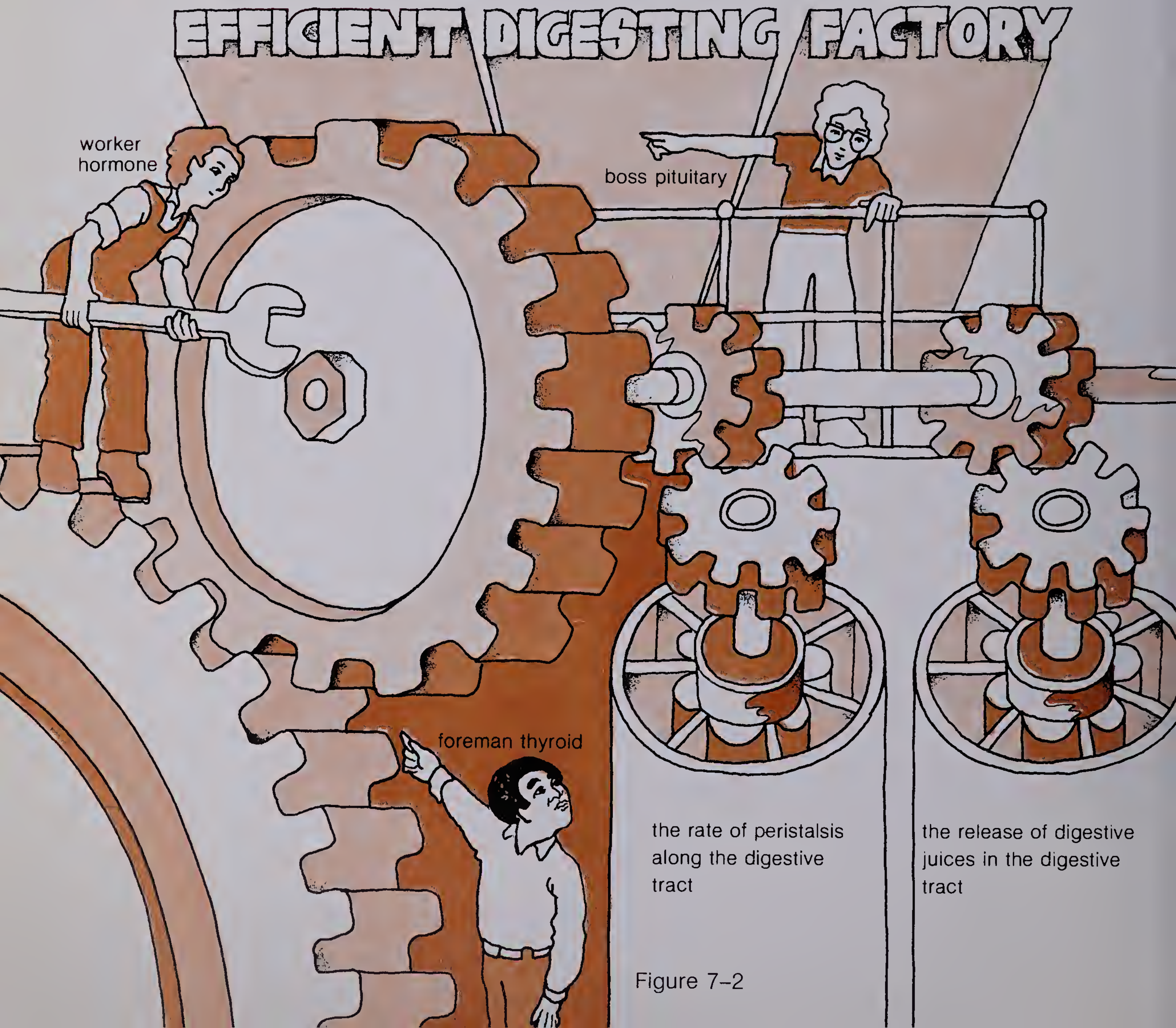
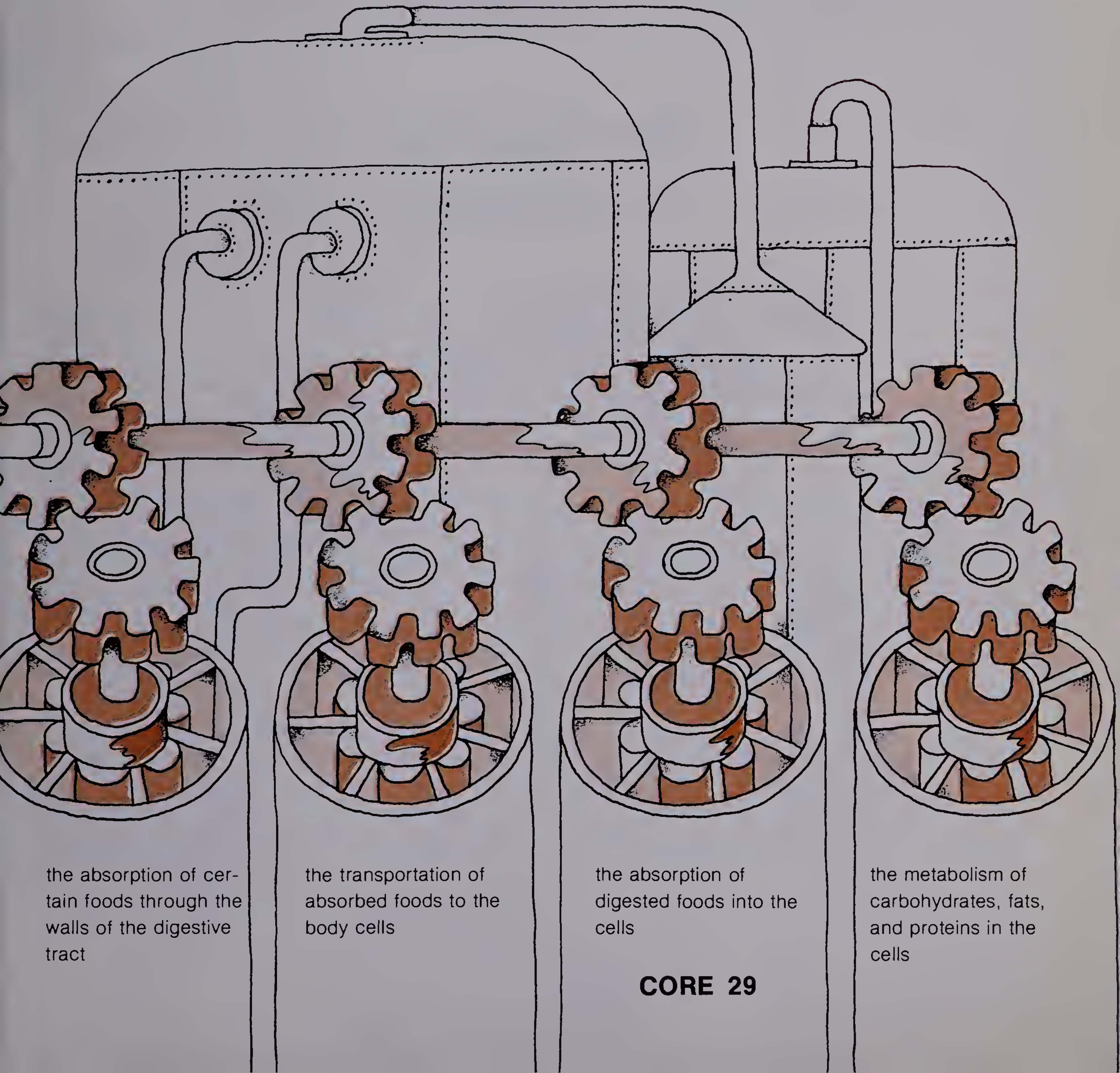


Figure 7–2

When the thyroid gets "lazy," the pituitary sends out TSH to stimulate the thyroid back into action. When the thyroid gets "carried away," the pituitary stops releasing TSH. Scientists call this kind of control *feedback*. Figure 7-3 shows how this works.

If this is the first time you have run into feedback, don't worry if its meaning isn't completely clear. You'll study feedback again in other minicourses. However, if you've seen feedback before, and are feeling uneasy about it, you may want to take a look at *Resource Unit 13*. It describes feedback in more detail.

Have *Resource Unit 13* available to aid students in understanding feedback.



Hormone Control

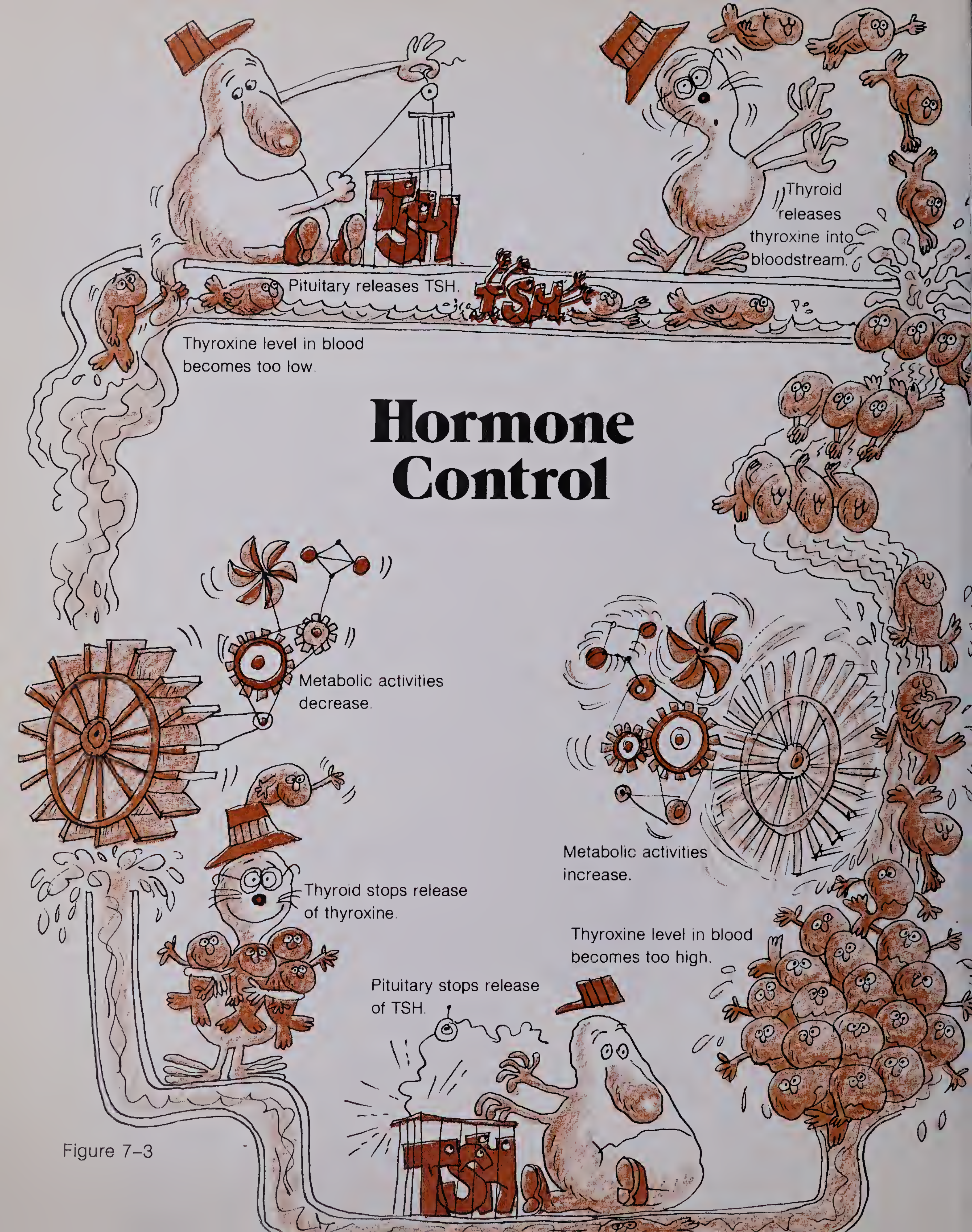


Figure 7–3

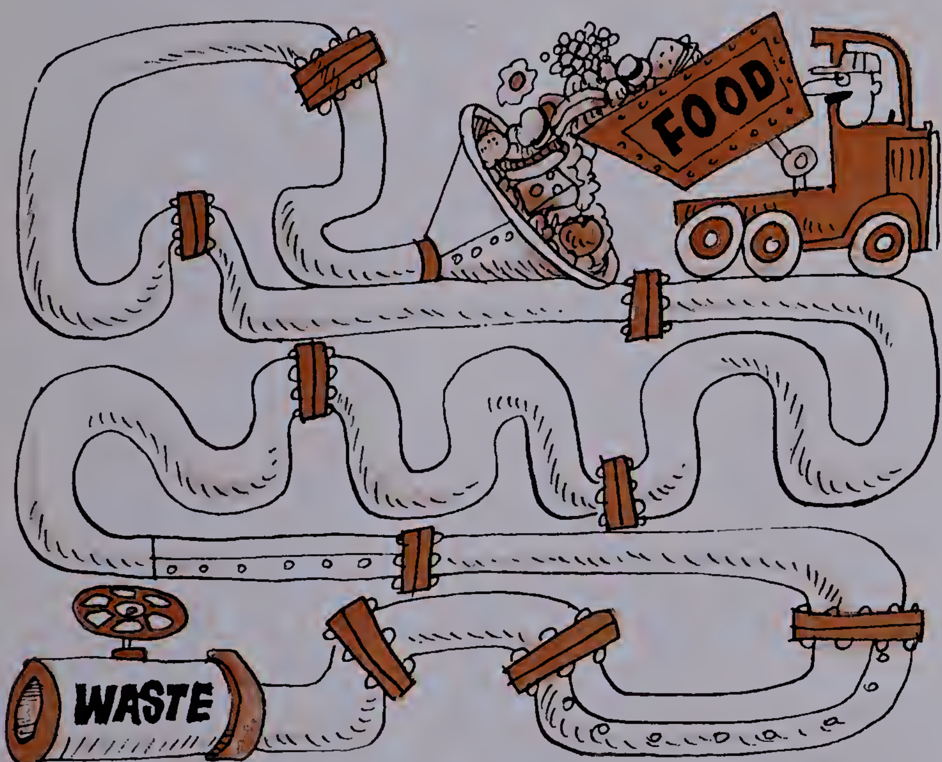
7–3. How does the pituitary gland regulate the activities of the thyroid gland?

7–4. Name six metabolic activities that are influenced by thyroxine.

★ 7–5. How is the release of digestive juices in the body sped up and slowed down?

Remember the cheeseburger? Now you've seen how its usable materials are metabolized by the body. Not usable as food for humans are the cellulose (from the tomato and lettuce) and possibly some of the excess fat (from meat, butter, and cheese). Undigested materials aid in cleaning out the gut. They are passed out of the body as waste with the *feces.*

Feces consist of all sorts of waste materials—water; mucus from the mouth, stomach, and intestines; bile from the liver; intestinal bacteria; dead intestinal cells; roughage (mostly plant fibers); fats; and gases such as carbon dioxide.



Think of all the food you've ever eaten—all the meals, all the snacks, all the liquids. You probably figure all that stuff is gone for good once you swallow it. But not so! Everything you ever ate is still around. In a different form, but still around. Whatever enters your digestive system is either used or eliminated.

7-3. By releasing or holding back TSH.

7-4. Rate of peristalsis, release of digestive juices, absorption of food, transportation of absorbed food, absorption of food into cells and metabolism of food cells.

7-5. Thyroxine stimulates the release of digestive juices. When the level of thyroxine is too low, the pituitary releases TSH. When the level of thyroxine is too high, the pituitary stops releasing TSH.

Since feces are not solely waste residues from food, during starvation the bulk of the feces may not be much less than normal.

Suppose you could track the smallest particles, or atoms, of each food you ate. You would find that each atom becomes part of something else—either part of the waste feces or of some cell somewhere. No atoms are destroyed and no new atoms are made in the process. This is called the *law of conservation of matter* because it is true for changes in all kinds of matter.

This may be the first time you've met the law of conservation of matter. If so, don't worry if the meaning isn't completely clear. You'll run into conservation again in other minicourses. If you have seen this law before and are uneasy about it, you may want to read *Resource Unit 18*. It describes conservation in more detail. Apply this idea to a meal of cheeseburger, cola, and french fries. Figure 7–4 shows what happens to the main parts of the meal.

Have *Resource Unit 18* available to aid students in understanding conservation.

✓ 7–6. Which contents of the meal would mostly become part of the feces? 7-6. Cellulose, some fats, and flavoring.

✓ 7–7. Which contents of the meal would mostly be used by the body? 7-7. Sugars, fats, proteins, starches, minerals, water, and vitamins.

✓ 7–8. Did you account for the six main nutrients (page 25) in Questions 7–6 and 7–7? 7-8. Yes.

★ **7–9. How does Figure 7–4 illustrate the law of conservation of matter?**

7-9. All the food eaten either becomes part of the body or is eliminated as breath, urine, sweat, or feces. No atoms are created or destroyed.

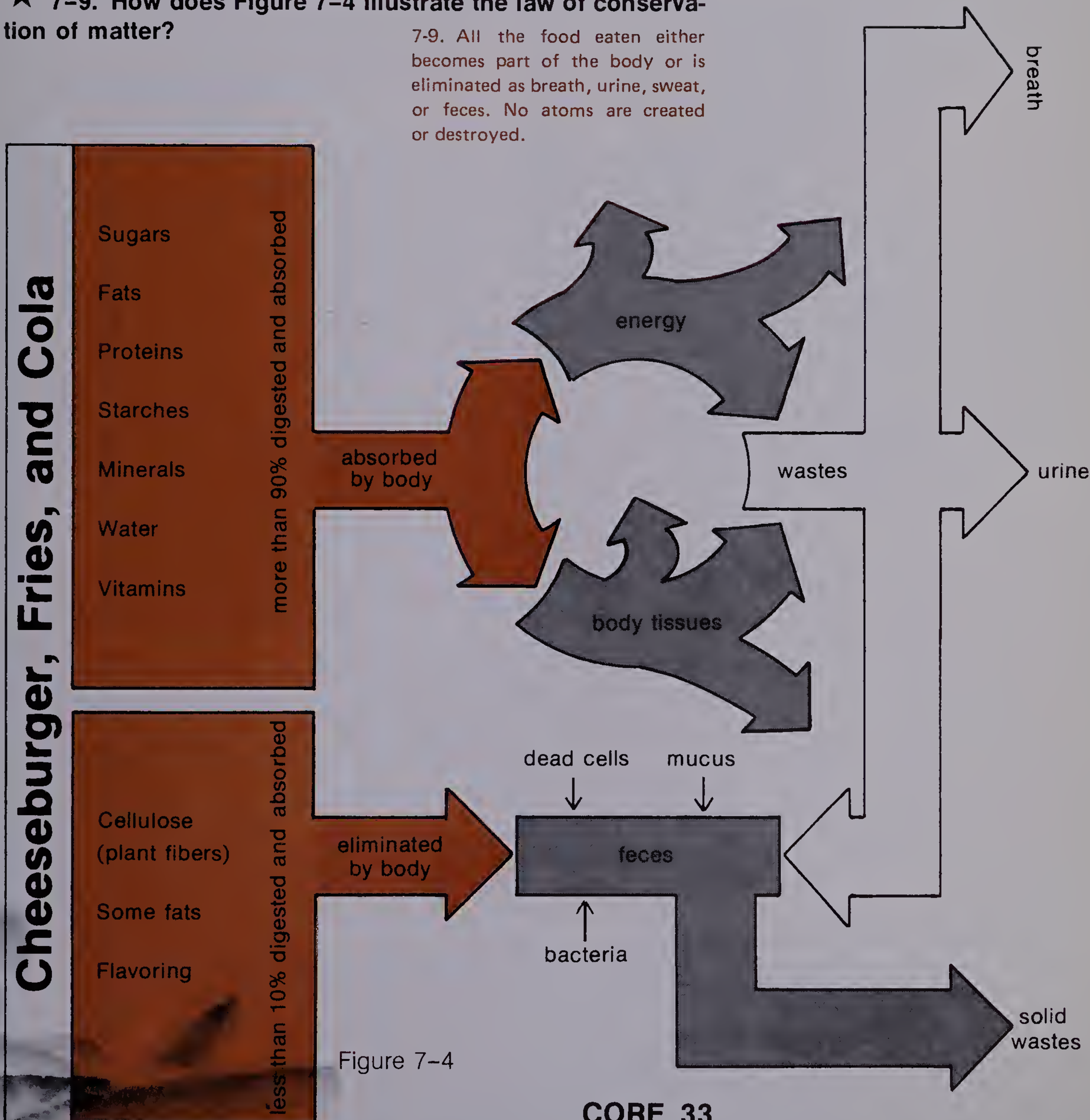


Figure 7–4

advanced

Activity 8 Planning

If you're not sure about Objective 9, do Activity 9 first. If you need to do the other two activities, you can do them in either order.

Activity 9 Page 36

Objective 9: Describe what a catalyst is and what it does in a chemical reaction.

Sample Question: Which of these statements is (are) true?

a. Catalysts are not all alike.
b. Catalysts are unchanged by reactions.
c. Catalysts slow reactions down.

Activity 10 Page 41

Objective 10: Describe the chemical composition of a digestive enzyme and explain what enzymes do in the digestive system.

Sample Question: Which of the following is (are) true of enzymes?

a. They help break down food in the gut.
b. They help combine foods in the gut.
c. They help villi to move and absorb food.
d. They help prepare food for absorption through the gut walls.

Objective 11: Predict how changes in pH, temperature, or concentration will affect the activity of enzymes.

Sample Question: What will increase the rate of enzyme activity?

a. increasing the temperature from 5°C to 37°C
b. diluting the enzyme to one part in a thousand
c. adding saliva to an acid solution

Activity 11 Page 56

Objective 12: Describe the digestion of starch and the action of amylase.

Sample Question: Which reaction is correct?

a. starch + hydrochloric acid $\xrightarrow{\text{amylase}}$ starch + water

b. starch + water $\xrightarrow{\text{amylase}}$ maltose

c. starch $\xrightarrow{\text{amylase}}$ water + sucrose

d. starch + hydrochloric acid $\xrightarrow{\text{amylase}}$ maltose

Objective 13: Describe the digestion of protein and the action of pepsin.

Sample Question: The enzyme pepsin

a. *is destroyed by acid.*

b. *splits protein into fatty acids.*

c. *digests protein in the stomach.*

d. *splits protein into its chain units.*

Objective 14: Explain and illustrate what is meant by the statement "digestive enzymes are specialized."

Sample Question: Which of these statements is (are) true?

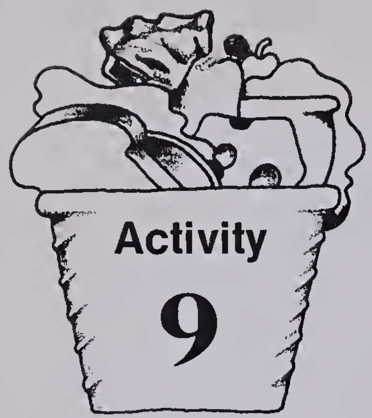
a. *Digestive enzymes can work at any pH.*

b. *Amylase enzymes digest starch in the mouth and small intestine.*

c. *Pepsin digests protein in the stomach and small intestine.*

Answers

9. a, b 10. a, d 11. a 12. b 13. c, d 14. b

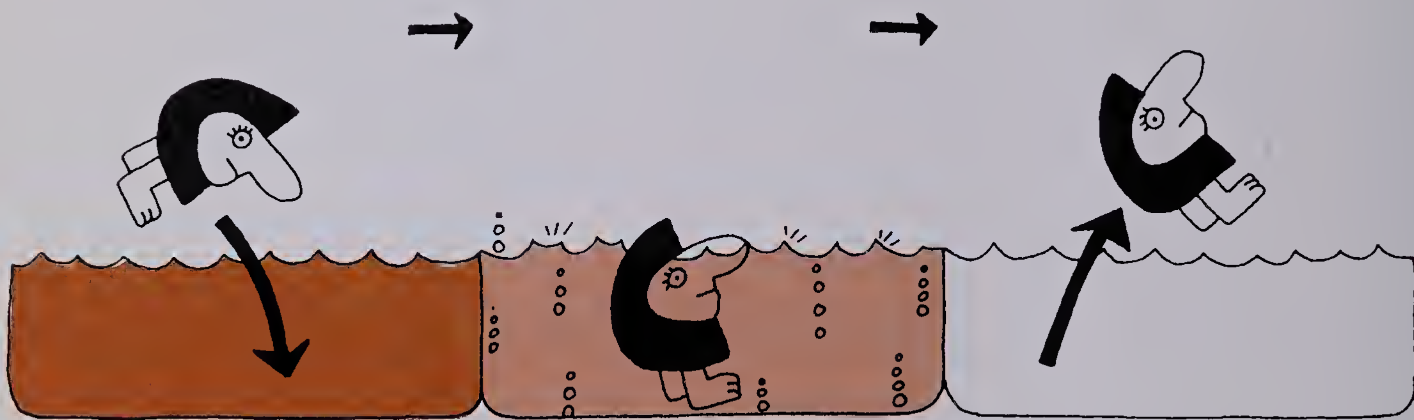


Catalysts

ACTIVITY EMPHASIS: The rate of decomposition of H_2O_2 is affected differently by different catalysts. Students investigate the decomposition of H_2O_2 by BB's, iron chloride, fresh raw liver, and other substances.

You may have heard the human body referred to as a very efficient machine. It certainly beats industry when it comes to demolition and construction. Take the breakdown of proteins, for instance. In the laboratory, proteins must be boiled in strong acid for about 24 hours before they will break down into simpler substances. Under normal conditions, your digestive tract gets the same results in less than four hours.

What makes the difference? A substance called a *catalyst* [KAT-al-ist]. Catalysts enter into and speed up certain chemical reactions. And though a catalyst becomes part of the reaction, it is still there, unchanged, at the end of the reaction. Catalysts are like shortcuts that reactions can take over and over again.



MATERIALS PER STUDENT UNIT
2 plastic straws, clear
cellophane tape
1-hole rubber stopper, #5
test tube, 25 x 150 mm
graduated cylinder, 25-ml
hydrogen peroxide, 3%
paper clip
metric ruler, 30 cm
5 copper-coated BB's
iron chloride
fresh raw liver
additional substances for Step G
Resource Unit 4
Resource Unit 5
For gas generator assembly see Advance Preparation, p. TM 6.

Catalysts are used to speed up many industrial processes, such as the breakdown of petroleum and the making of ammonia. Inside the body, catalysts are called *enzymes*. One important enzyme reaction that occurs inside the body is the breakdown, or decomposition, of hydrogen peroxide (H_2O_2), a poisonous byproduct of certain cellular reactions. Hydrogen peroxide decomposes into harmless water and oxygen:

$$2H_2O_2 \xrightarrow[\text{(body temperature)}]{\text{enzyme}} 2H_2O + O_2$$

At body temperature, this reaction would go too slowly without the help of an enzyme. Likewise, at room temperature, a catalyst must be added to speed up the same breakdown:

$$2H_2O_2 \xrightarrow[\text{(room temperature)}]{\text{catalyst}} 2H_2O + O_2$$

To see this happening, you will need the following items:

See Advance Preparation, p. TM 6, for details on assembling the gas generator.

- gas generator
- graduated cylinder
- dilute hydrogen peroxide (H_2O_2)

CAUTION

Hydrogen peroxide can bleach your clothes and skin.

Hydrogen peroxide should be fresh. See Advance Preparation, p. TM 7, for details on making this solution.

For stains wash immediately with lots of cool water.

- paper clip
- metric ruler
- 5 copper-coated BBs
- iron chloride
- fresh raw liver
- additional substances as suggested in Step G (page 40)

Select the additional materials and have them available for students to use.

Before you begin, copy Figure 9–1 into your notebook. Leave space below your table; you'll be adding more data to the table when you do Step G.

DECOMPOSITION OF H_2O_2

CONTENTS OF TUBE	HEIGHT OF LIQUID IN STRAW		TOTAL DISTANCE LIQUID ROSE
	AT START	AFTER 2 MIN.	
H_2O_2			
H_2O_2 + copper			
H_2O_2 + iron chloride			
H_2O_2 + raw liver			

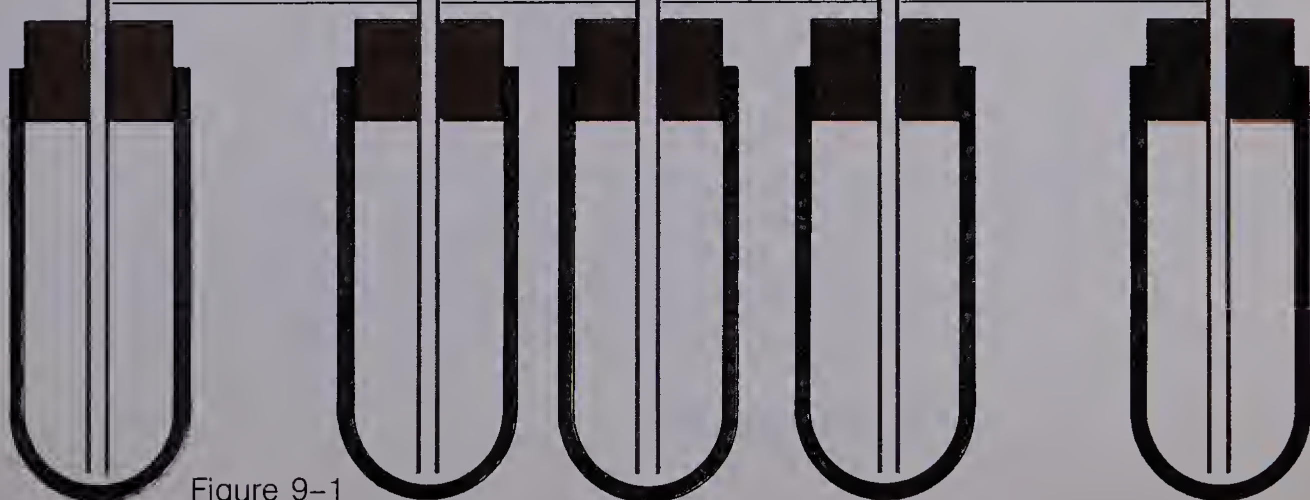


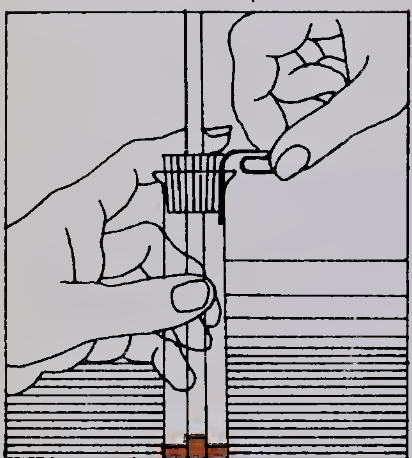
Figure 9–1

Have *Resource Unit 5* available to aid students in using the graduated cylinder.

A. Remove the stopper from the gas generator. Add 5 ml of H_2O_2 to the test tube. If you have trouble using the graduated cylinder, refer to *Resource Unit 5*. Unbend one side of a paper clip and rest it on the mouth of the tube as shown.

IMPORTANT: Avoid holding the test tube at the bottom. This is to prevent heating the hydrogen peroxide.

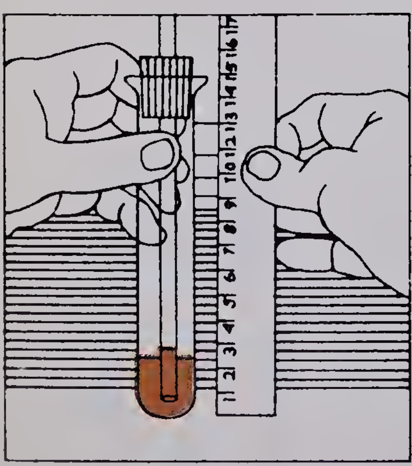
Remove clip when liquid levels are about equal.



straw about 1 mm from bottom

B. Push the stopper into the test tube. Holding the stopper in place, pull out the paper clip. The liquid in the straw should be at or near the level of the liquid in the test tube. If not, remove the stopper and repeat the procedure with the paper clip until the levels are about equal.

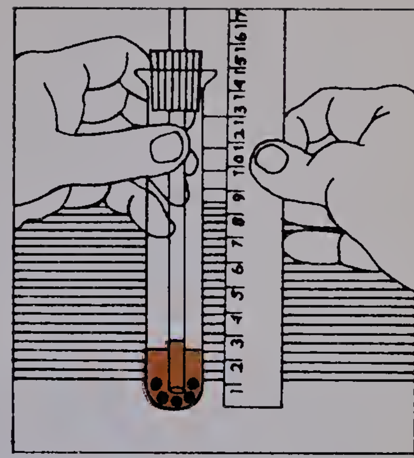
This procedure makes the gas pressure about the same inside and outside the generator.



height of liquid in straw

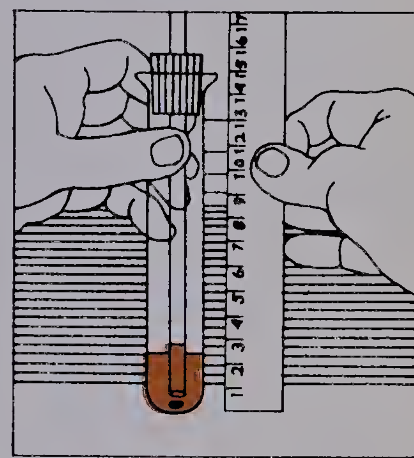
C. Place the metric ruler next to the gas generator and record in millimetres the height of the liquid in the straw. After 2 minutes, measure and record the height again. Compute and record the total number of millimetres the liquid rose.

D. Remove the stopper and add 5 copper-coated BBs to the liquid in the test tube. Using the bent paper clip, replace the stopper. Observe and record the liquid levels as you did in Step C. Then wash out the generator.



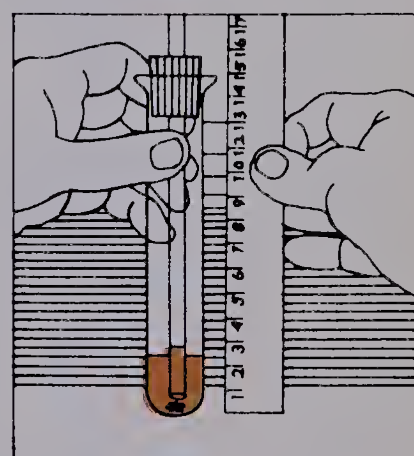
H_2O_2 + 5 copper BBs

E. To the clean generator, add 5 ml of H_2O_2 and a piece of iron chloride about the size of 2 BBs. Stopper the tube using the bent paper clip. Observe and record the liquid levels as in Step C. Then wash out the generator.



H_2O_2 + iron chloride

F. To the clean generator, add 5 ml of H_2O_2 and a piece of raw liver about the size of 2 BBs. Stopper the tube using the bent paper clip. Observe and record the liquid levels as in Step C. Then wash out the generator.



H_2O_2 + raw liver

9-1. The heights of the bars will depend on the purity of the catalysts used, but in general the bar for liver will be highest, and the bar for iron chloride higher than that for the BB's, which will be higher than that for H_2O_2.

9–1. Make a bar graph of your findings. (If you need help in making graphs, refer to *Resource Unit 4*.)
Have *Resource Unit 4* available to aid students in making graphs.

9–2. Which substance(s) increased the decomposition of hydrogen peroxide? 9-2. Copper-coated BB's, iron chloride, and raw liver.

9–3. Which substance was the most active catalyst (raised the level of the liquid highest)? 9-3. Raw liver.

9–4. Does your bar graph confirm the role of a catalyst in a reaction? Explain your answer.

9-4. Yes. The graph shows that the materials added increased the rate of the reactions, and the materials appeared to be unchanged.

9–5. Hydrogen peroxide bubbles when it is used to clean out a wound. What might this tell you about human tissues?
9-5. That they might contain catalysts for the decomposition of H_2O_2.

A lot of substances will catalyze the decomposition of hydrogen peroxide. And a lot won't.

G. Repeat the procedure with the gas generator, using 5 ml of H_2O_2 each time. Add various substances and record the results in your table. You might try plastic, glass, washing powder, candle wax, plant leaves, dried yeast, detergent, different metals, galvanized nails, steel nails, pencil "lead," sugar, table salt, saliva, and so on. Add the results to your graph.

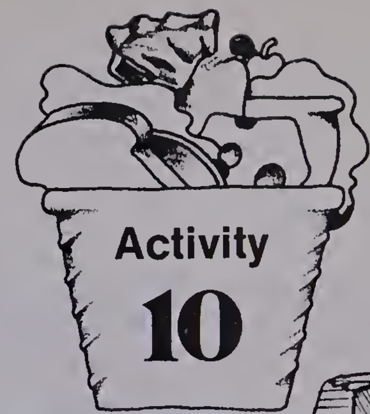
9-6. Answers will vary, but in general materials such as leaves and yeast are good catalysts, while glass, plastic, sugar, and wax are not catalysts for this reaction.

9-7. It increases the rate.

✓ 9–6. Of the substances you tried in Step G, which, if any, acted as catalysts for the hydrogen peroxide reaction? Which did not?

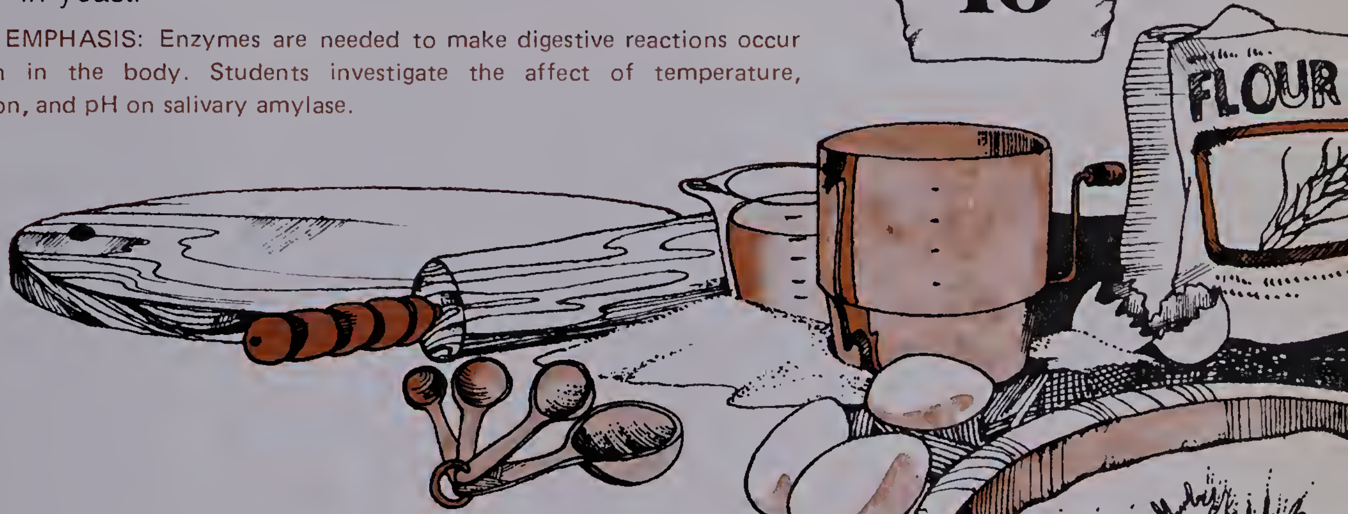
★ **9–7. How does a catalyst affect the rate of a chemical reaction?**

Enzymes



Many different reactions are necessary for the life and growth of plants and animals. The catalysts that make these reactions occur fast enough are called *enzymes,* a name derived from the Greek for "in yeast."

ACTIVITY EMPHASIS: Enzymes are needed to make digestive reactions occur fast enough in the body. Students investigate the affect of temperature, concentration, and pH on salivary amylase.

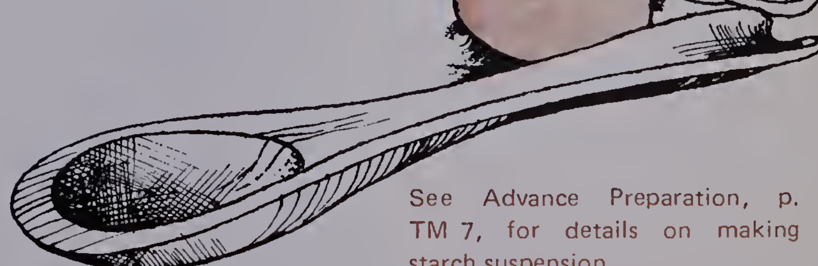


Because they are catalysts, enzymes are not affected by the reactions they enter into. They are harmed only by wear and tear or by poisoning. A lot of questions can be raised about enzymes: Does temperature influence their effect? Does even more enzyme mean an even faster reaction? How specific are enzymes? What are they made of?

You'll find the answer to each of those questions as you do the investigations in this activity. Most of the investigations require about 45 minutes to do, so plan to spend four or five days with this activity. You will probably want to work with a partner.

The enzyme you will be experimenting with is *salivary amylase* [AM-i-lays], the main enzyme in your saliva. You may recall that saliva breaks down starch into sugar. Get the following to learn the tests for starch and sugar:

a partner (if you wish)
starch suspension
graduated cylinder
test tube
stirring rod
glucose-sensitive tape
Lugol's solution
medicine dropper
glucose solution



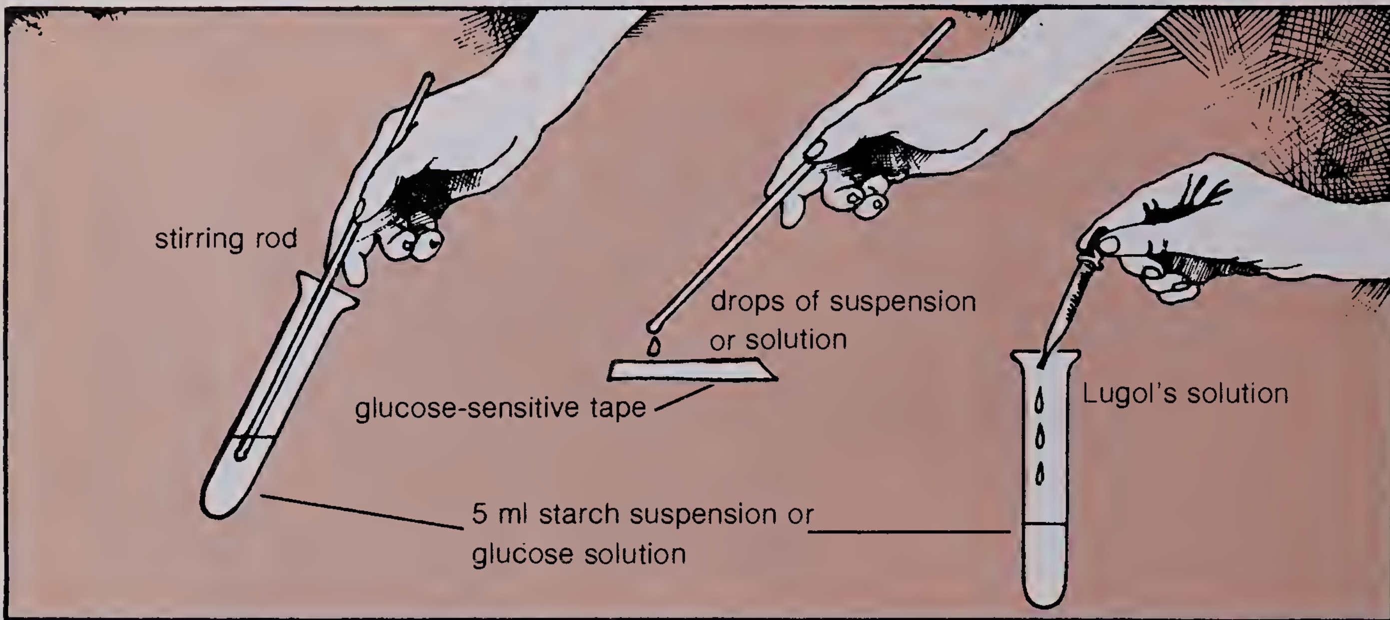
See Advance Preparation, p. TM 7, for details on making starch suspension.

See Advanced Preparation, p. TM 7, for details on making Lugol's solution.

See Advanced Preparation, p. TM 7, for details on making glucose solution.

Iodine stains may be removed from clothing by soaking the stain in a 10% solution of sodium thiosulfate in water. Then wash with water.

Put 5 ml of starch suspension in a clean test tube. Test the suspension with glucose-sensitive tape, then with a few drops of Lugol's solution. Wash the test tube thoroughly and repeat the procedure with 5 ml of glucose solution.



MATERIALS PER STUDENT UNIT
starch suspension, 100 ml
graduated cylinder, 25-ml
7 test tubes, 20 x 150 ml
stirring rod
glucose-sensitive tape, 50 cm
Lugol's solution
medicine dropper
glucose solution, 5 ml
3 beakers, 250-ml
grease pencil
thermometer, Celsius
ice cubes
rubber bands, 5
distilled water, 100 ml
test-tube rack
watch or clock with second hand
pipette, 5-ml
olive oil, 0.5 ml
sodium bicarbonate solution, 20 ml
cooked egg white, 2 pieces
hydrochloric acid, 25 ml
pH test paper with dispenser, 20 cm
sodium hydroxide, 5 ml
acetic acid, 0.25 ml
Biuret reagent, 10 drops
Resource Unit 7

✔ 10–1. How do you test for starch? 10-1. Lugol's solution turns from amber to purple when added to a substance containing starch.

✔ 10–2. How do you test for sugar? 10-2. Drops of a substance containing sugar will color glucose-sensitive tape blue or dark green.

Now that you've seen how starch and sugar (glucose) test out, you're ready to investigate questions about enzymes.

TEMPERATURE

★ **10–3. How does temperature influence enzyme activity?** (If you can answer this question and Question 10–8, you don't need to do the following investigation. Skip to Question 10–9.)
10-3. Enzymes are most active within a particular temperature range.

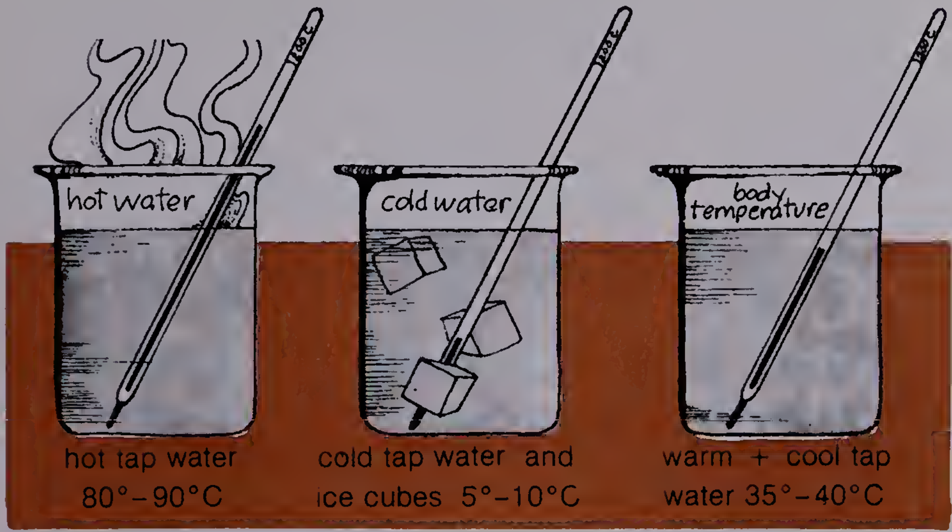
To find out whether temperature affects enzymes, you will need:

a partner (if you wish)	7 test tubes
3 beakers, 250-ml	stirring rod
grease pencil for labeling	glucose-sensitive tape
thermometer, Celsius	clean rubber band
ice cubes	distilled water
graduated cylinder	test-tube rack
starch suspension	watch or clock with second hand

See Advanced Preparation, p. TM 7, for details on making starch suspension.

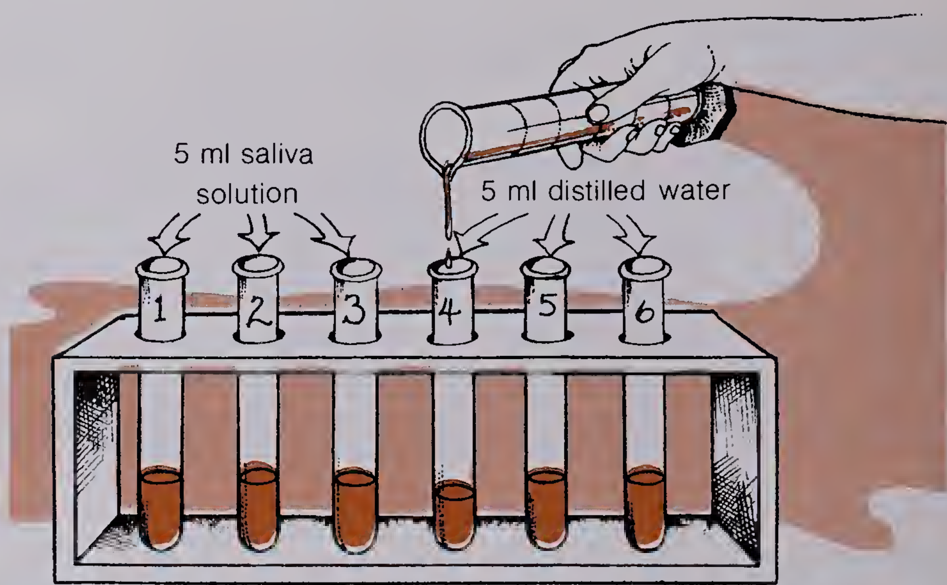
A. Label three breakers: *hot water, cold water,* and *body temperature*. Fill the beakers ¾ full according to the directions in the illustration.

Provide a hot plate if water must be heated.



B. Chew on a clean rubber band to produce saliva. Collect 7 or 8 ml of saliva in a clean test tube. Then add enough distilled water to make 15 ml of saliva solution. Shake the test tube gently to mix the solution.

C. Label six clean test tubes from *1* to *6* and place them in a test-tube rack. Add 5 ml of starch suspension to each test tube. Then add 5 ml of saliva solution to Tubes 1, 2, and 3 only. Wash out the graduated cylinder and add 5 ml of distilled water to Tubes 4, 5, and 6 only.



D. Put Tubes 1 and 4 in the beaker of hot water; put Tubes 2 and 5 in the beaker of cold water; put Tubes 3 and 6 in the beaker of water at body temperature. Every 2 minutes for 20 minutes, use glucose-sensitive tape to test the contents of each tube for the presence of sugar. Record your observations in your notebook. You may want to use a table similar to the one shown in Figure 10–1.

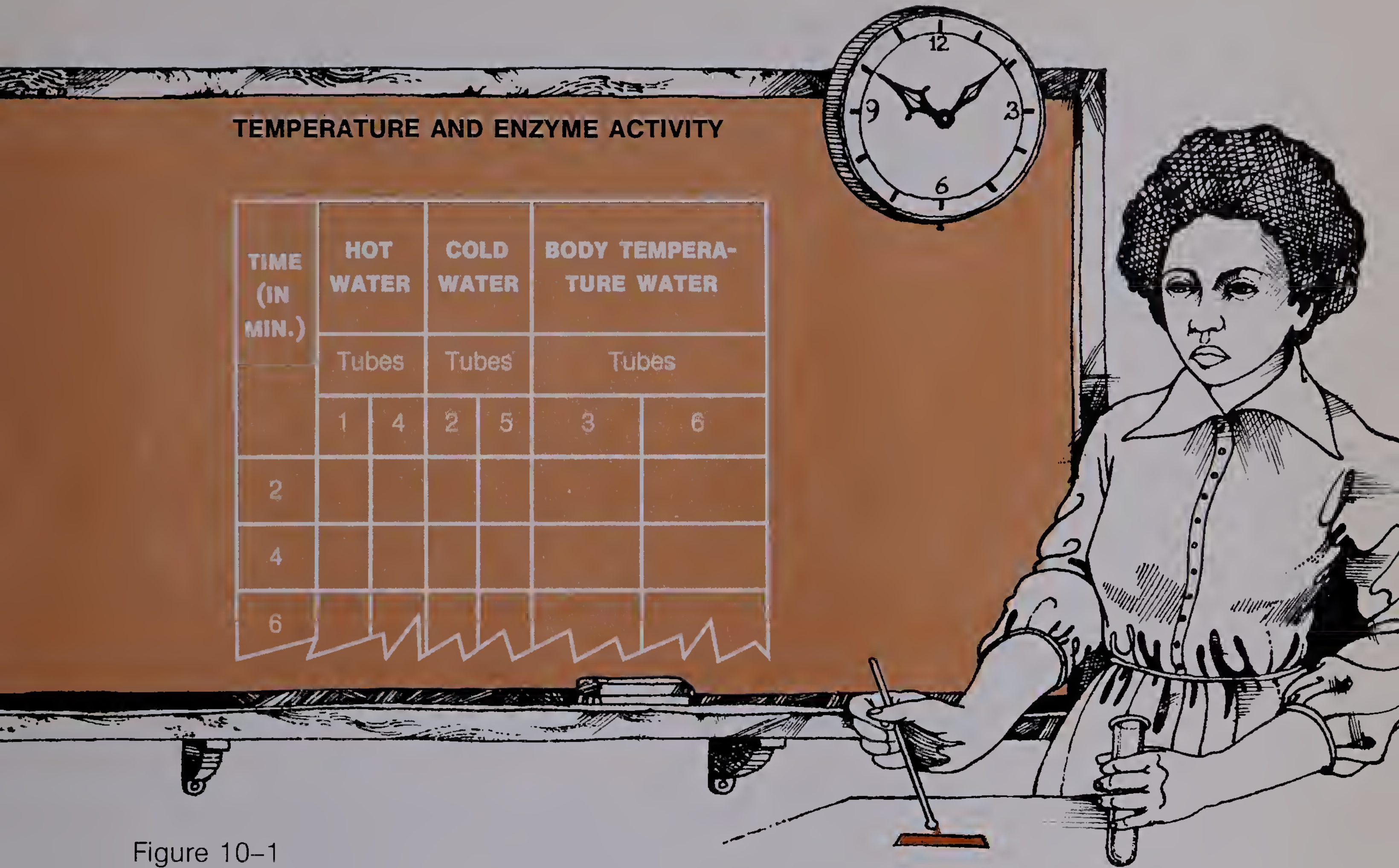


Figure 10–1

✔ 10–4. At which temperature did you get the first positive test for sugar? The last positive test?

10-4. Body temperature; hot water.

✔ 10–5. At which temperature did the reaction go fastest?

10-5. Body temperature.

✔ 10–6. Consider the setup of the investigation. How do you know that salivary amylase, rather than something in the distilled water or starch suspension, was responsible for the presence of sugar?

10-6. At each temperature there was a test tube with saliva and one without. The test tube with only starch and water never gave a positive test for sugar.

✔ 10–7. Do your data confirm that temperature has something to do with the rate of starch digestion? Explain your answer.

10-7. Yes, since the rate was greatest at one temperature than at the other two.

★ **10–8. Suppose you were stranded somewhere without shelter and the temperature dropped below freezing. How might your body's enzyme activity be changed?**

10-8. It might be reduced when the body temperature dropped.

AMOUNT

10-9. The greater the amount of enzyme, the greater the rate of the reaction.

★ **10–9. What, if anything, does the amount of an enzyme have to do with the rate of a reaction?** (If you can answer this question and Question 10–13, skip to Question 10–14.)

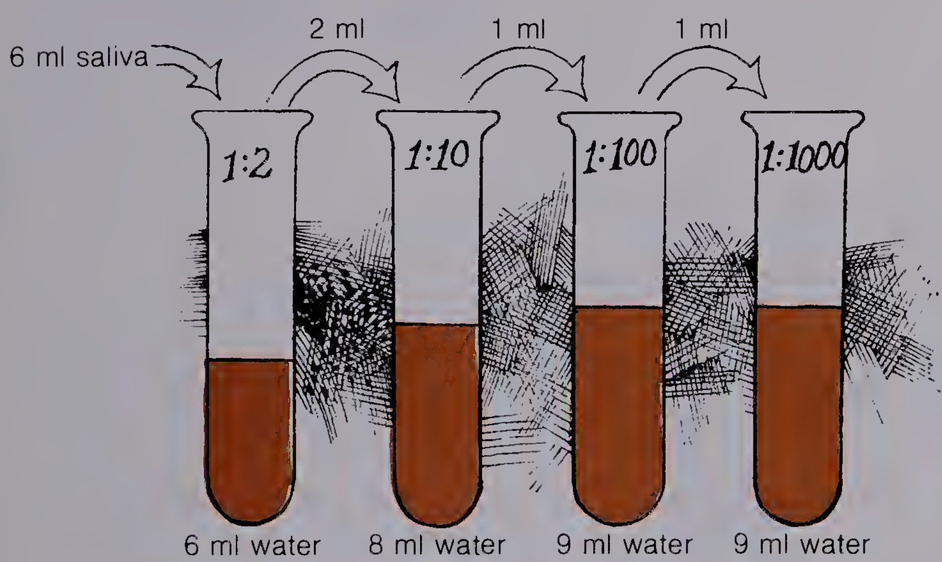
To find out how the concentration of an enzyme influences the rate of a reaction, you will need the following:

See Advanced Preparation, p. TM 7, for details on making starch suspension.

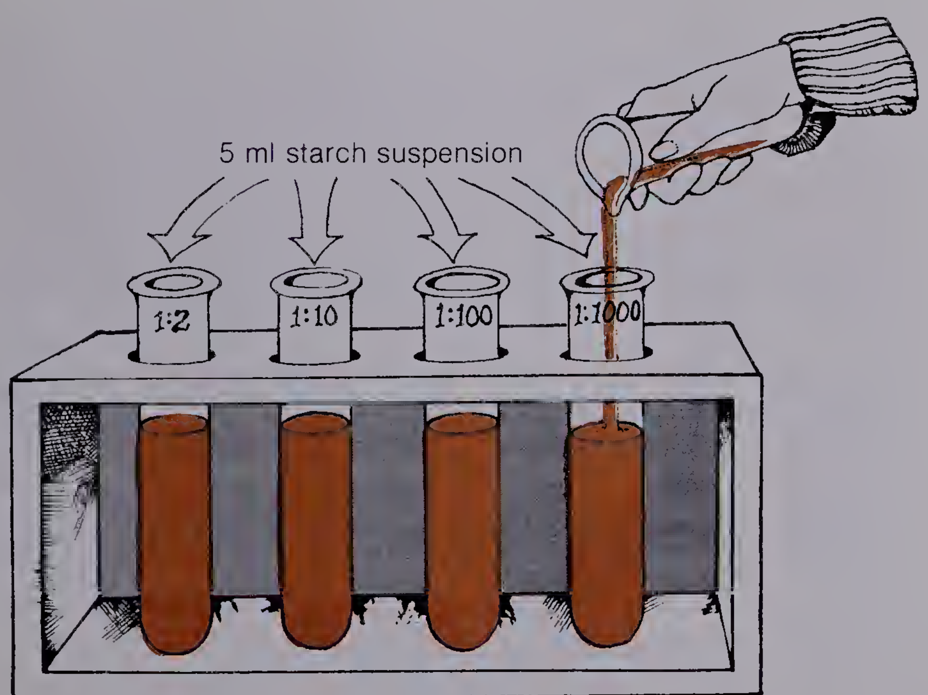
- a partner (if you wish)
- 5 test tubes
- grease pencil for labeling
- clean rubber band
- graduated cylinder
- distilled water
- test-tube rack
- pipette
- starch suspension
- stirring rod
- glucose-sensitive tape
- watch or clock with second hand

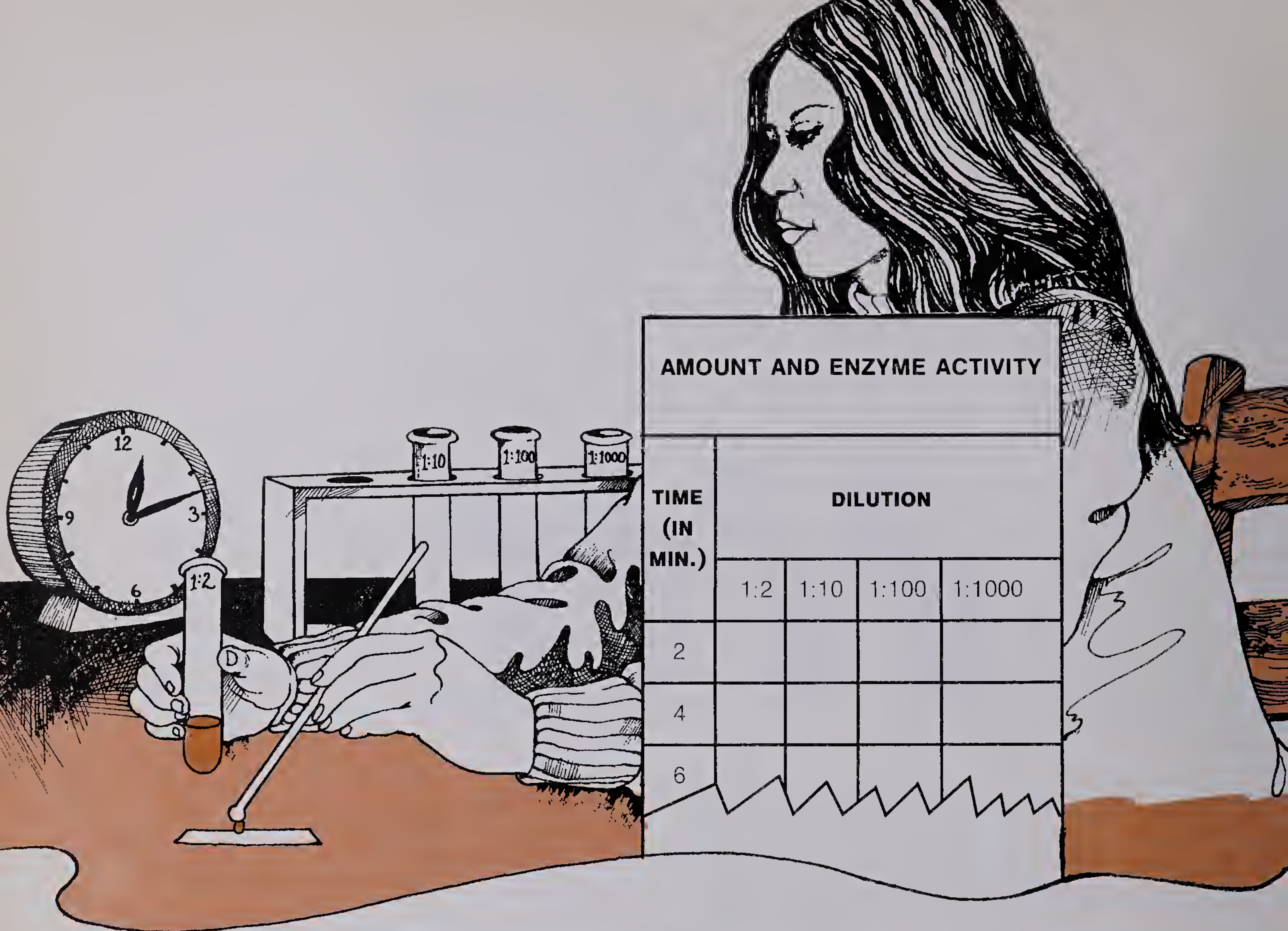
A. Label a clean test tube *1:2*. Chew on a clean rubber band to produce saliva, and collect 6 ml of saliva in the tube. Add 6 ml of distilled water. This gives you a 1:2 dilution (one part saliva to two parts solution). Shake the tube well, then place it in a test-tube rack.

B. Label three more test tubes *1:10, 1:100,* and *1:1000.* To get the 1:10 dilution, use a pipette to transfer 2 ml of the 1:2 dilution into the 1:10 test tube. Add 8 ml of distilled water to get a 1:10 dilution. Get the 1:100 and 1:1000 dilutions by following the illustration's directions.



C. Add 5 ml of starch suspension to each of the four test tubes. Then, every 2 minutes for 20 minutes, use glucose-sensitive tape to test each tube for the presence of sugar. Record your data in a table similar to the one shown in Figure 10–2.





AMOUNT AND ENZYME ACTIVITY				
TIME (IN MIN.)	DILUTION			
	1:2	1:10	1:100	1:1000
2				
4				
6				

Figure 10–2

✔ 10–10. Which dilution first showed a positive test for sugar? Which dilution was last? 10-10. 1:2; 1:1000

10-11. 1:2, 1:1000

✔ 10–11. In which dilution did the reaction proceed most rapidly? Least rapidly?

10-12. Diluting reduces its ability.

★ **10–12. How does diluting the concentration of salivary amylase influence its ability to break down starch?**

10-13. Everything else is the same from test tube to test tube.

✔ 10–13. Consider the setup of the investigation. How can you be sure that your results are due only to the diluting of saliva with distilled water?

FOOD SPECIFICITY

10-14. Very specific.

★ **10–14. How specific are enzymes?** (If you can answer this question and Question 10–17, skip to Question 10–18.)

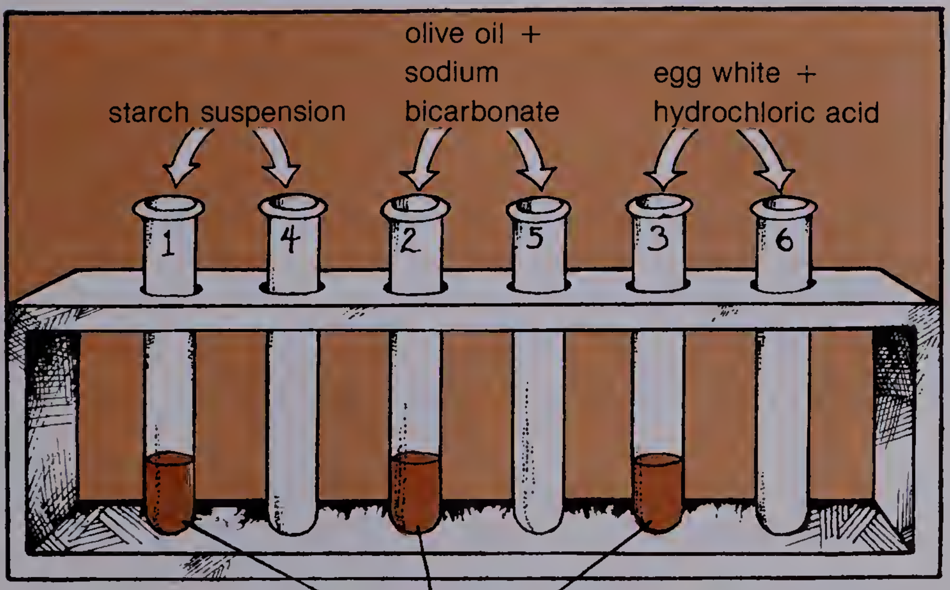
Will salivary amylase break down any foods besides starch? To find out, you will need the following:

- a partner (if you wish)
- clean rubber band
- 7 test tubes
- graduated cylinder
- distilled water
- grease pencil for labeling
- test-tube rack
- starch suspension
- olive oil
- medicine dropper
- sodium bicarbonate solution
- cooked egg white
- dilute hydrochloric acid
- beaker, 250-ml
- thermometer, Celsius
- stirring rod
- glucose-sensitive tape
- watch or clock with second hand

A. Chew on a clean rubber band to produce saliva. Collect about 7 or 8 ml in a clean test tube. Add enough distilled water to make 15 ml of saliva solution. Gently shake the test tube to mix the solution.

B. Label six clean test tubes from *1* to *6* and place them in a test-tube rack. Do the following to the test tubes. Be sure to wash out the graduated cylinder after each use.

1. To Tubes 1, 2, and 3, add 5 ml of saliva solution.
2. To Tubes 1 and 4, add 10 ml of starch suspension.
3. To Tubes 2 and 5, add 2 drops of olive oil *and* 10 ml of sodium bicarbonate solution.
4. To Tubes 3 and 6, add a pea-sized piece of cooked egg white *and* 10 ml of dilute hydrochloric acid.



See Advanced Preparation, p. TM 7, for details on making starch suspension.

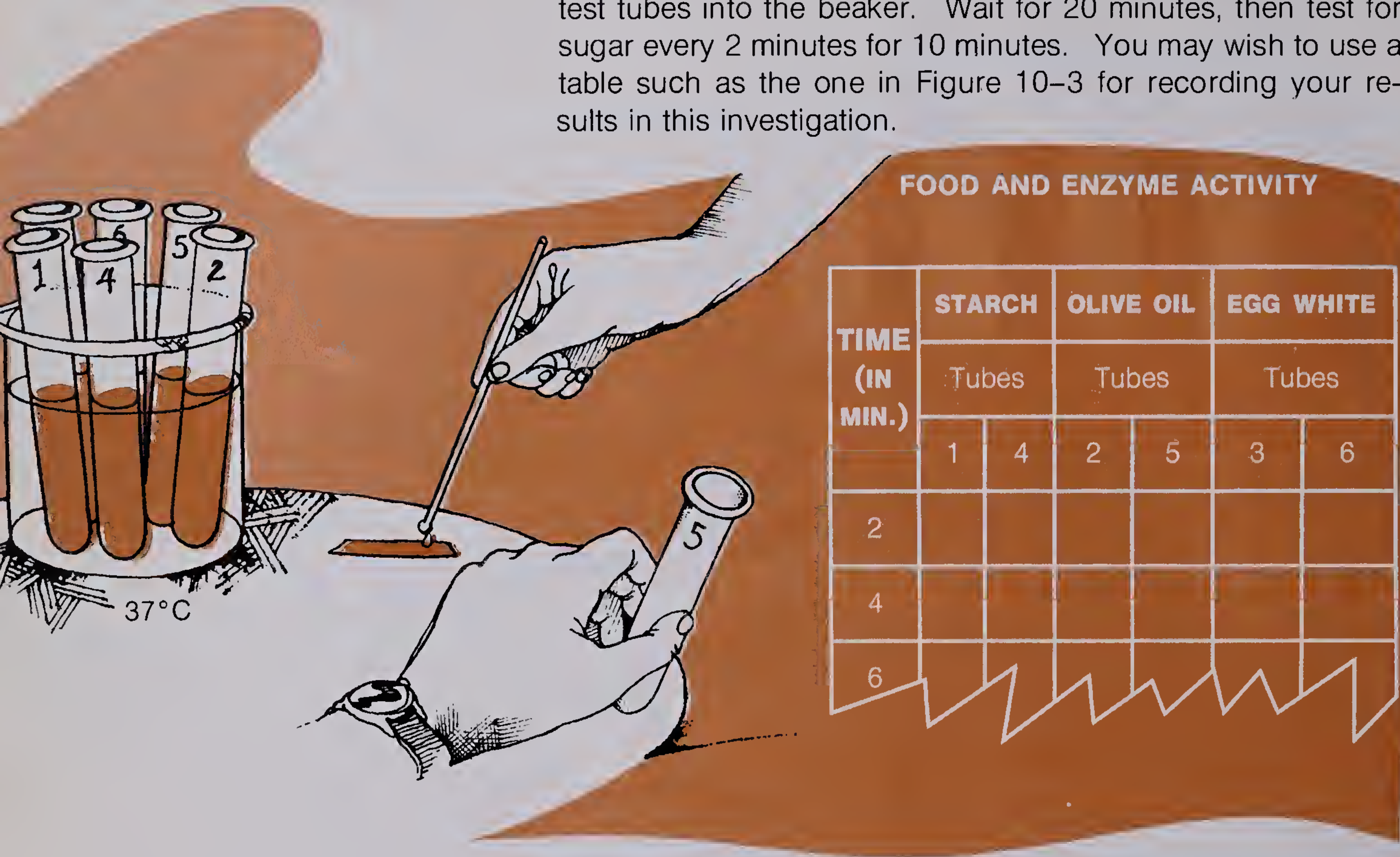
See Advanced Preparation, p. TM 7, for details on making $NaHCO_3$ solution.

See Advanced Preparation, p. TM 8, for details on making the cooked egg white.

See Advanced Preparation, p. TM 7, for details on making HCl solution.

Caution students to handle HCl carefully, since it can irritate skin and damage clothing.

C. Fill a beaker ¾ full with water at or near 37°C. Put the six test tubes into the beaker. Wait for 20 minutes, then test for sugar every 2 minutes for 10 minutes. You may wish to use a table such as the one in Figure 10–3 for recording your results in this investigation.



TIME (IN MIN.)	STARCH		OLIVE OIL		EGG WHITE	
	Tubes		Tubes		Tubes	
	1	4	2	5	3	6
2						
4						
6						

Figure 10–3

10-15. Tube 1; no.

✔ 10–15. In which test tube did the first positive test for sugar occur? Did the other tubes test positive for sugar later?

10-16. No; no; There was no sugar in Tube 2 or Tube 3 after being subjected to salivary amylase.

✔ 10–16. Does salivary amylase break down fats (olive oil)? Proteins (egg white)? Support your answers with evidence from the investigation.

10-17. Repeat the investigation using pepsin in place of saliva.

★ **10–17. Design an experiment to show that the enzyme pepsin is specific for protein digestion.** (You may want to do the experiment if you have time.)

pH SPECIFICITY

10-18. Yes.

★ **10–18. Enzymes are said to be pH specific. Is this true of salivary amylase?** (If you can answer this question and Question 10–22, skip to Question 10–23. If you don't know what pH means, see *Resource Unit 7* before doing the investigation.)

Have *Resource Unit 7* available to aid students in understanding pH.

To find out if salivary amylase is pH specific, you will need the following:

- a partner (if you wish)
- pH test paper and dispenser with color-code chart
- clean rubber band
- graduated cylinder
- 4 test tubes
- grease pencil for labeling
- test-tube rack
- distilled water
- starch suspension
- dilute hydrochloric acid
- dilute sodium hydroxide
- beaker, 250-ml
- thermometer, Celsius
- stirring rod
- glucose-sensitive tape
- watch or clock with second hand

A. Wet a piece of pH paper on your tongue. Find the pH by using the color-code chart on the dispenser.

See Advance Preparation, p. TM 7, for details on making starch suspension.

See Advanced Preparation, p. TM 7, for details on making HCl solution.

See Advanced Preparation, p. TM 7, for details on making NaOH solution.

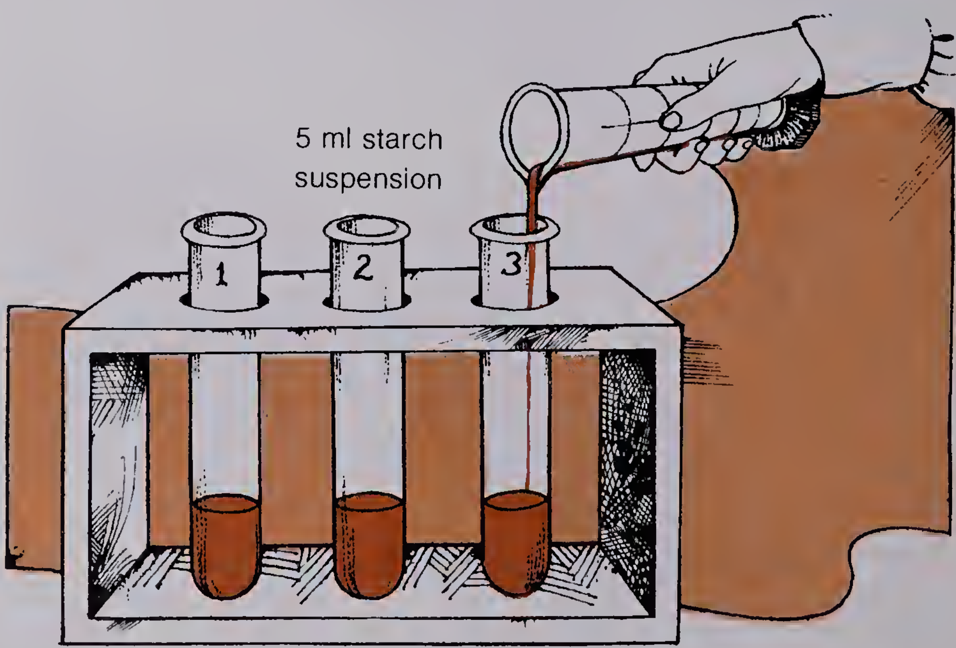
Caution students to handle HCl and NaOH carefully, since they can irritate skin and damage clothing.

✓ 10-19. What is the pH of your mouth?

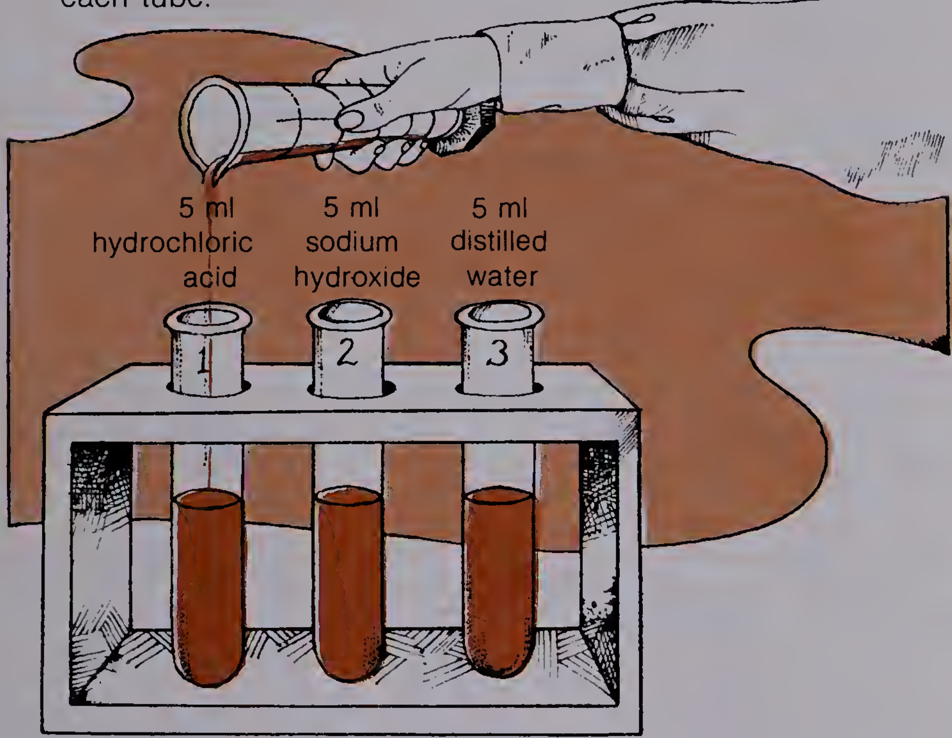
10-19. About 6.

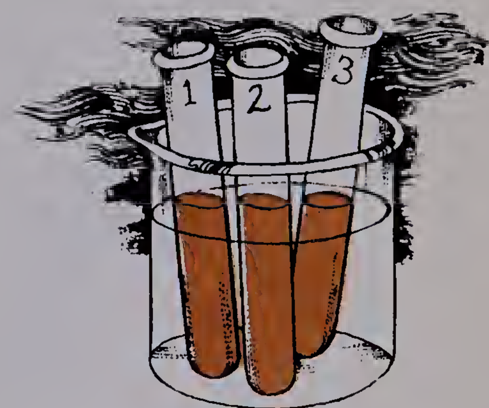
B. Chew on a clean rubber band to produce saliva. Collect about 7 or 8 ml in a clean test tube. Add enough distilled water to make 15 ml of saliva solution. Gently shake the test tube to mix the solution.

C. Label three clean test tubes from *1* to *3*. Into each test tube, put 5 ml of saliva solution and 5 ml of starch suspension.



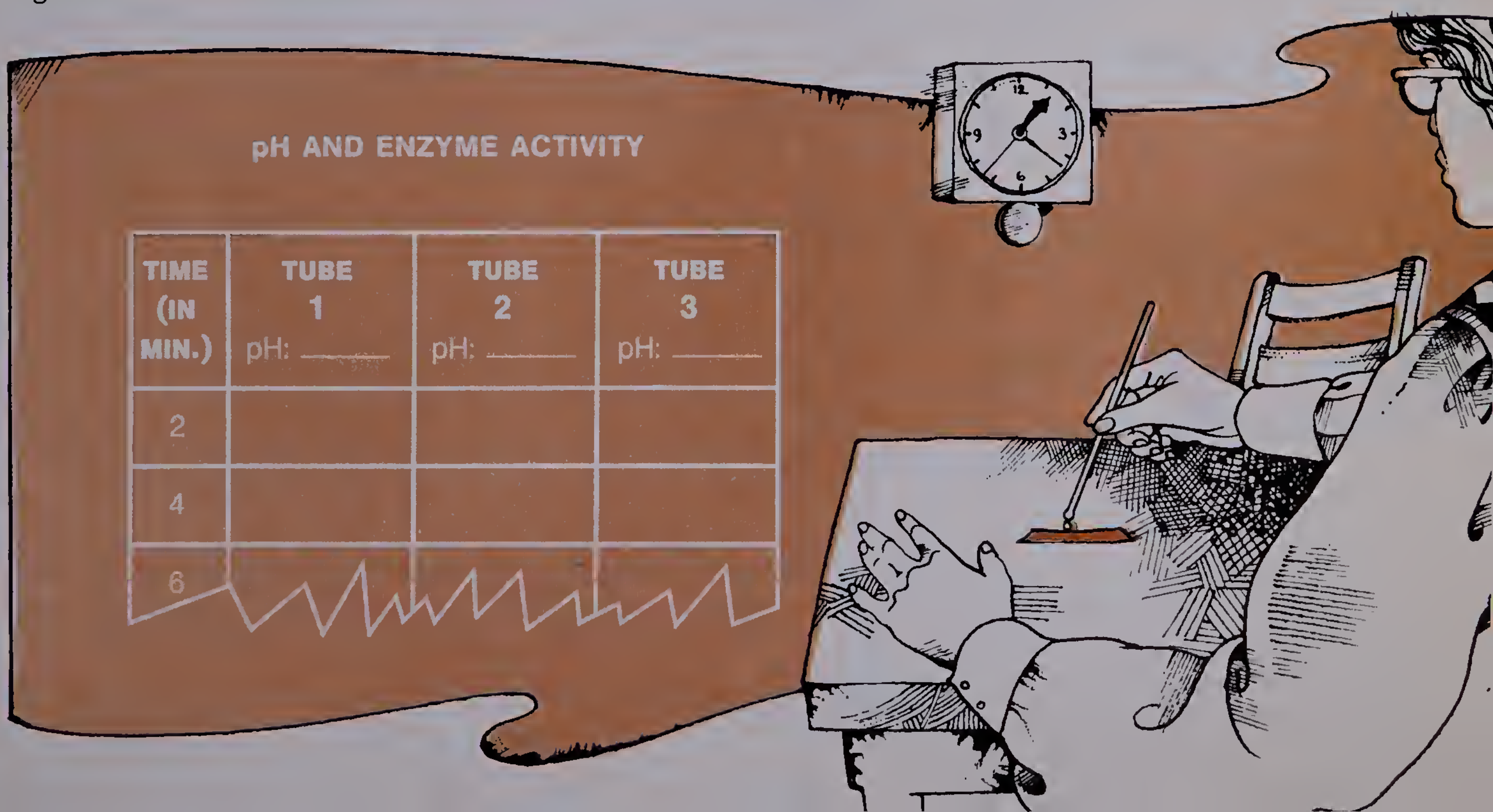
D. To Tube 1, add 5 ml of dilute hydrochloric acid. Don't forget to wash out the graduated cylinder after each use. To Tube 2, add 5 ml of dilute sodium hydroxide. To Tube 3, add 5 ml of distilled water. Find and record the pH of the solution in each tube.





E. Fill a beaker ¾ full of water at or near 37°C. Put the three tubes in the beaker. Wait 10 minutes, then test for sugar every 2 minutes for 10 minutes. Record your results in your notebook. You might use a table like the one in Figure 10–4.

Figure 10–4



pH AND ENZYME ACTIVITY

TIME (IN MIN.)	TUBE 1 pH: ____	TUBE 2 pH: ____	TUBE 3 pH: ____
2			
4			
6			

10-20. Tube 3; no.

✔ 10–20. In which test tube did the first positive test for sugar occur? Did the other tubes show a positive test later?

10-21. Starch is changed to sugar fastest when the pH is near neutral. Adding an acid or base stops the enzyme.

✔ 10–21. How does the pH of a solution influence the digestion of starch? Support your answer with evidence from the investigation.

10-22. No. The enzymes that affect the digestion of starch work only at a pH near 7.

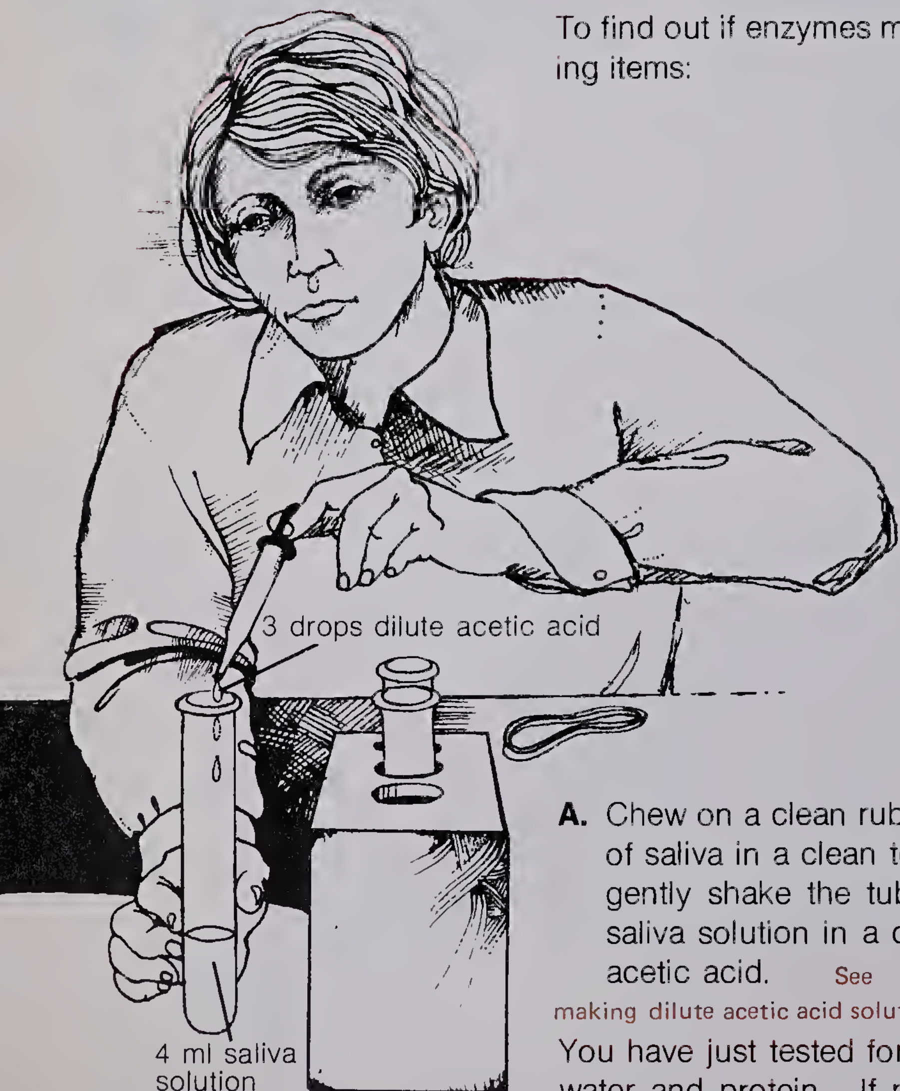
✔ 10–22. Protein digestion in the stomach requires a pH of about 2. Is it possible for starch to be digested in the stomach? Explain.

MAKEUP

10-23. Protein.

★ **10–23. What are enzymes made of?** (If you can answer this question and Question 10–27, you have finished the investigations in this activity.)

To find out if enzymes might be proteins, you will need the following items:



a partner (if you wish)
clean rubber band
3 test tubes
distilled water
test-tube rack
graduated cylinder
dilute acetic acid
medicine dropper
Biuret reagent

A. Chew on a clean rubber band to produce saliva. Collect 4 ml of saliva in a clean test tube. Add 4 ml of distilled water and gently shake the tube to mix the solution. Put 4 ml of the saliva solution in a clean test tube and add 3 drops of dilute acetic acid. See Advanced Preparation, p. TM 7, for details on making dilute acetic acid solution.

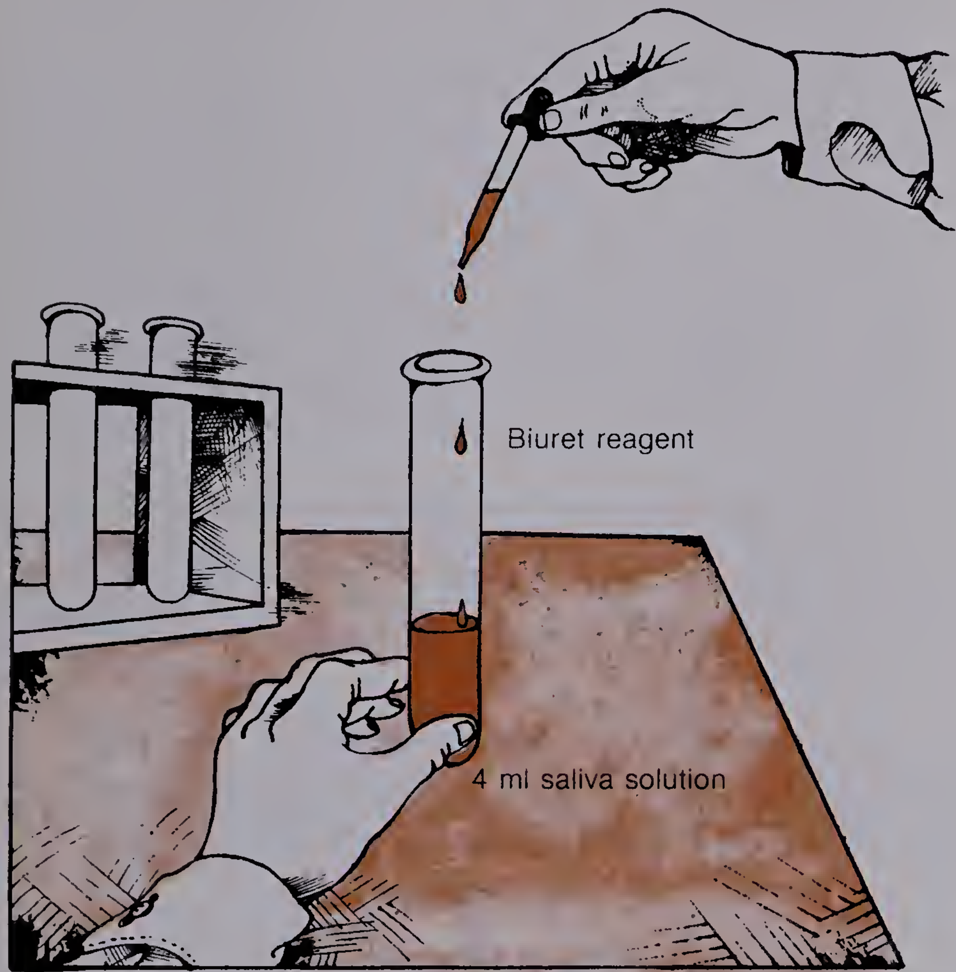
You have just tested for the presence of mucus, which is mostly water and protein. If mucus is present, the saliva gets lumpy.

See Advanced Preparation, p. TM 7, for details on making Biuret reagent.

✓ 10–24. Is mucus present in your saliva?

10-24. Yes.

B. Put 4 ml of saliva solution in a clean test tube. Add Biuret reagent, drop by drop, until there is a color change.



If the solution became a violet or pink-violet color, you got a positive test for protein.

✓ 10–25. Is protein present in your saliva?

10-25. Yes.

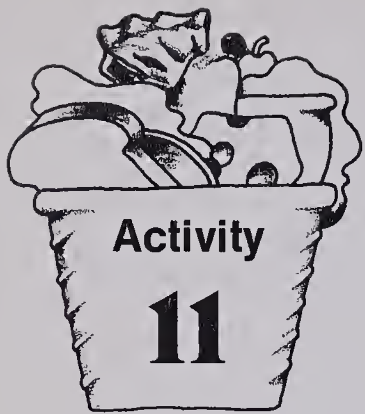
So, what do you have? You know that mucus is mostly water and protein. You know that your saliva contains an enzyme. But do you have any evidence that enzymes are proteins?

✓ 10–26. Why isn't the investigation you just did proof that enzymes are proteins?

10-26. It showed that saliva contains proteins, but since the mucus in saliva contains proteins it doesn't prove that the enzyme is protein.

✓ 10–27. Suppose the enzyme were the only substance in saliva other than water. Would that prove it was a protein?

10-27. Yes.



Gut Reactions Specialists

ACTIVITY EMPHASIS: The action of amylase in starch digestion and of pepsin in protein digestion. An important characteristic of enzymes is that they are specialized.

During digestion, food substances are broken down by a chemical process called *hydrolysis* [high-DROLL-i-sis]. The prefix *hydro-* refers to water. In hydrolysis, large food substances are split into subunits by the addition of water. Like most reactions in the body, hydrolysis is dependent on the action of enzymes.

The hydrolysis of starch is brought about by *amylase* [AM-i-lays] enzymes. The amylase in saliva, or salivary amylase, begins the digestion of starch in the mouth. Starch is actually a long chain of glucose molecules. Salivary amylase breaks down starch by breaking some of the bonds that chain the glucose molecules together.

The glucose molecules are separated from the starch in twos (see Figure 11–1). The freed ends of the paired glucose molecules attract parts of water (H_2O) molecules from the saliva. Molecules of the sugar maltose, chains of two glucose molecules, are formed.

MATERIALS PER STUDENT UNIT
None.

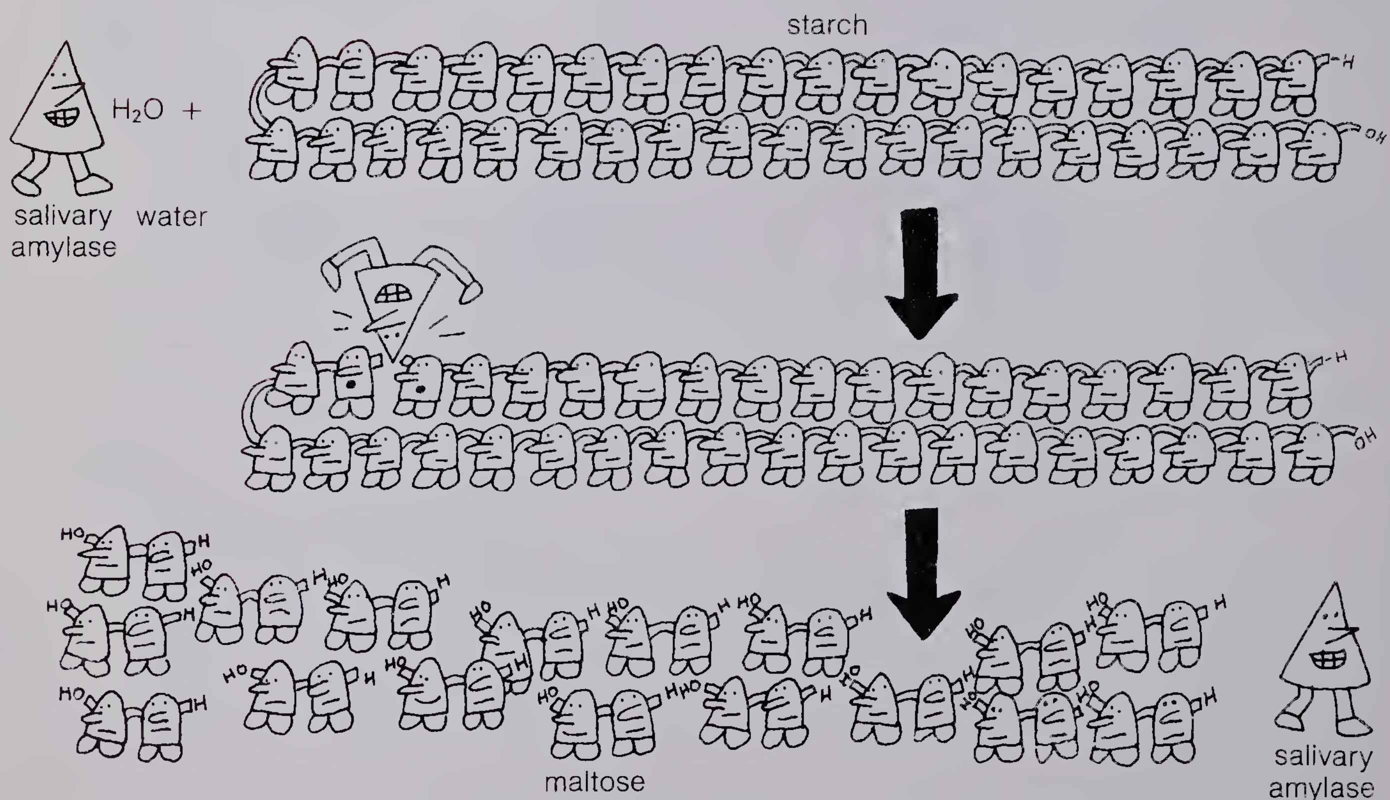


Figure 11–1

✔ 11–1. What is formed from the reaction shown in Figure 11–1? 11-1. Maltose.

An important characteristic of enzymes is shown in Figure 11–1. They make reactions occur without themselves being used up or changed. Enzymes are also very specific—they're specialists! Salivary amylase, for instance, can break bonds within starch molecules only. It has no effect on fats and proteins.

Amylase is also specific to its surroundings, unable to work in an acid environment such as the stomach. For this reason, no starch digestion occurs in the stomach. But starch is still present because the food didn't stay in the mouth long enough for the salivary amylase to finish its job. So in the small intestine, an amylase from the pancreas continues the breakdown of starch to maltose.

The amylase from the pancreas is many times more powerful than salivary amylase.

It remains now for the maltose molecules to be broken down into glucose molecules (Figure 11–2). Still in the small intestine, the enzyme *maltase* completes the digestion of starch by breaking down maltose. Again, parts of water molecules attach to the freed ends of the new molecules.

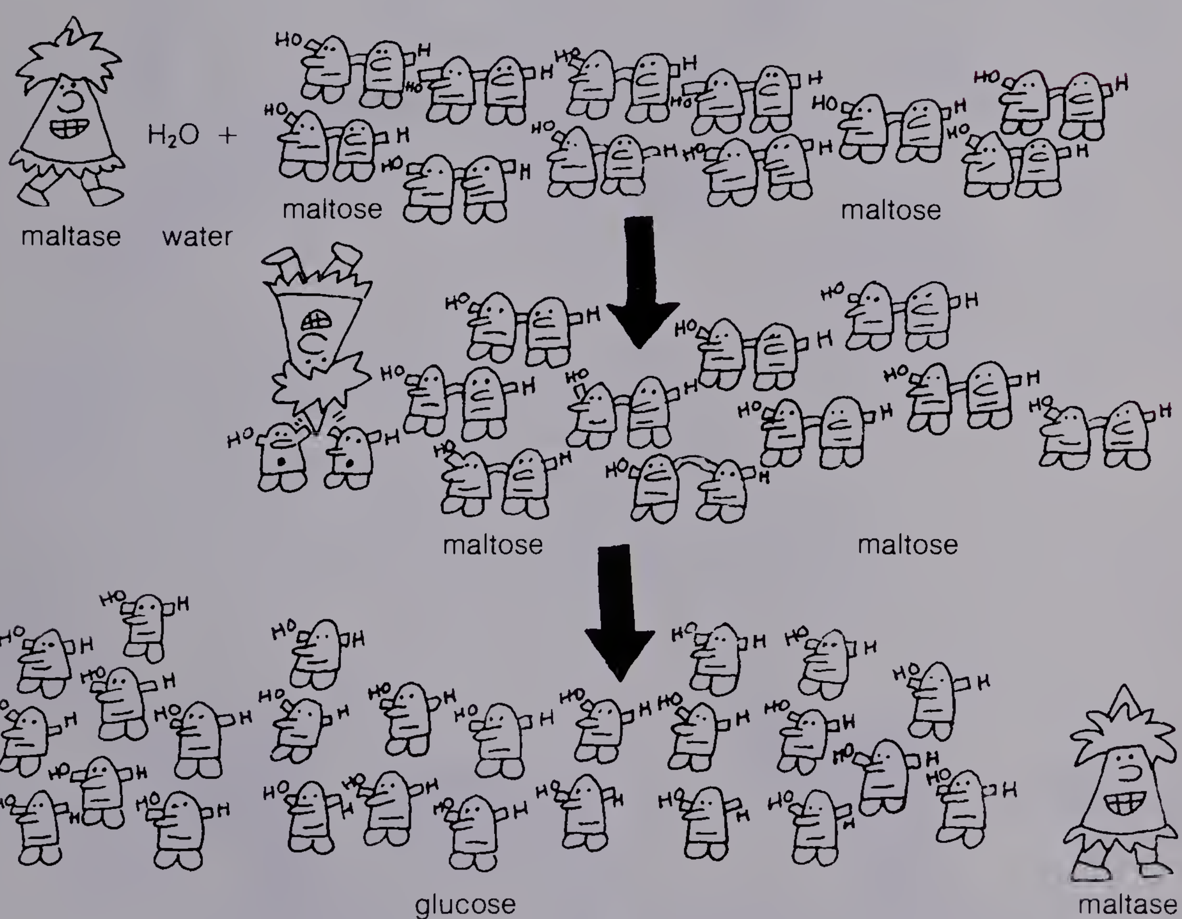


Figure 11–2

✔ 11–2. What is formed from the reaction shown in Figure 11–2? 11-2. Glucose.

The process of starch digestion can be shown as follows:

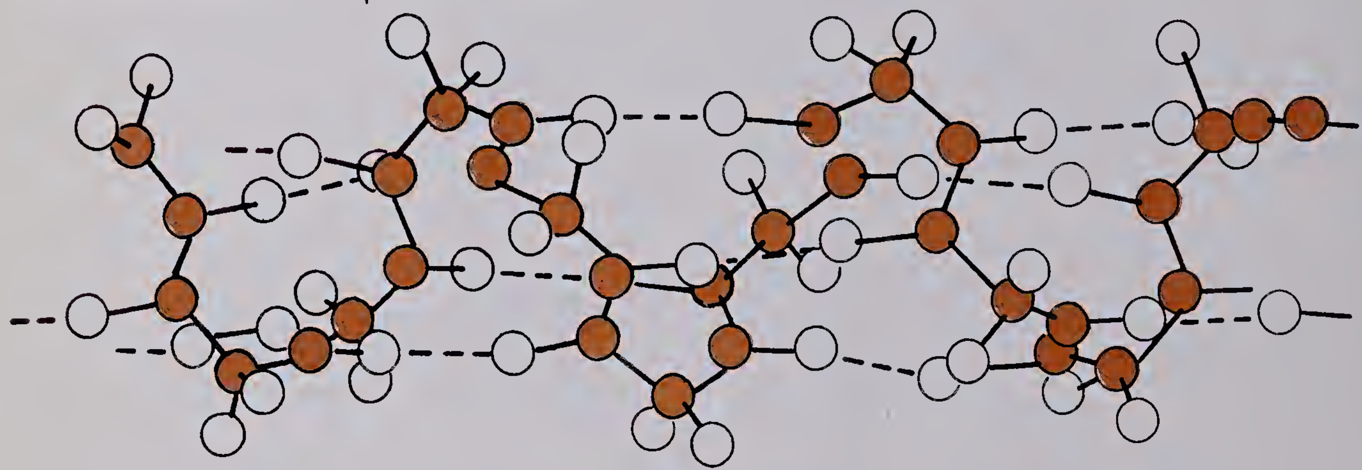
$$\text{starch} + \text{water} \xrightarrow{\text{amylase}} \text{maltose} + \text{water} \xrightarrow{\text{maltase}} \text{glucose}$$

11-3. Salivary amylase and pancreatic amylase split starch into pairs of glucose molecules (maltose) in the mouth and small intestine. In the small intestine, the pairs of glucose molecules are split apart by maltase.

The glucose can be absorbed through the villi and taken up by the bloodstream for transport to the body's cells. There, most of the glucose is used to provide energy.

★ **11–3. Describe in your own words how starch is completely digested in the body.**

a ball and stick model of a protein molecule



Proteins, like starch, are very large molecules. But where starch consists of glucose subunits, proteins consist of *amino acid* subunits. There are about twenty different kinds of amino acids. The differences are in the number of carbon, oxygen, and hydrogen atoms and in the arrangements of those atoms. But what makes them all amino acids is that they each have an amino part *(NH_2)* and an acid part *(COOH)*.

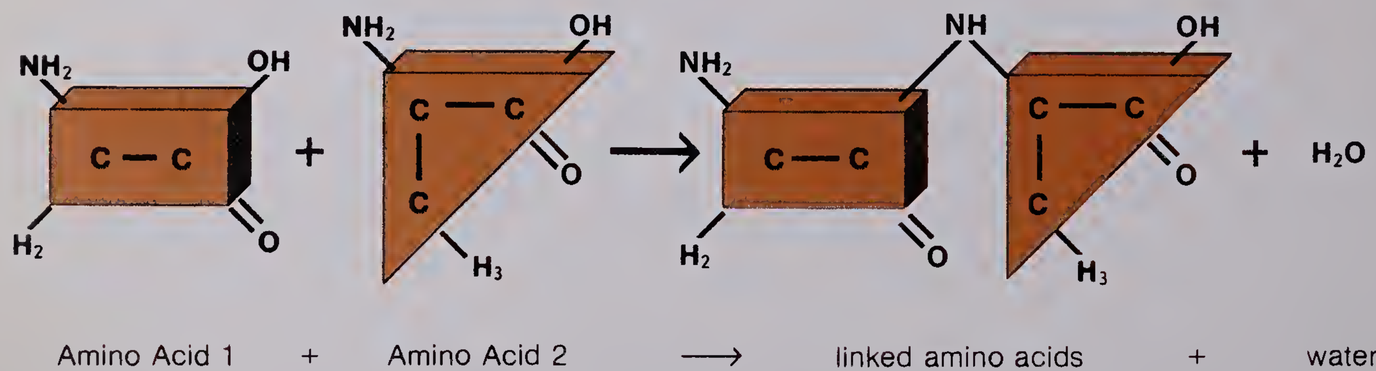
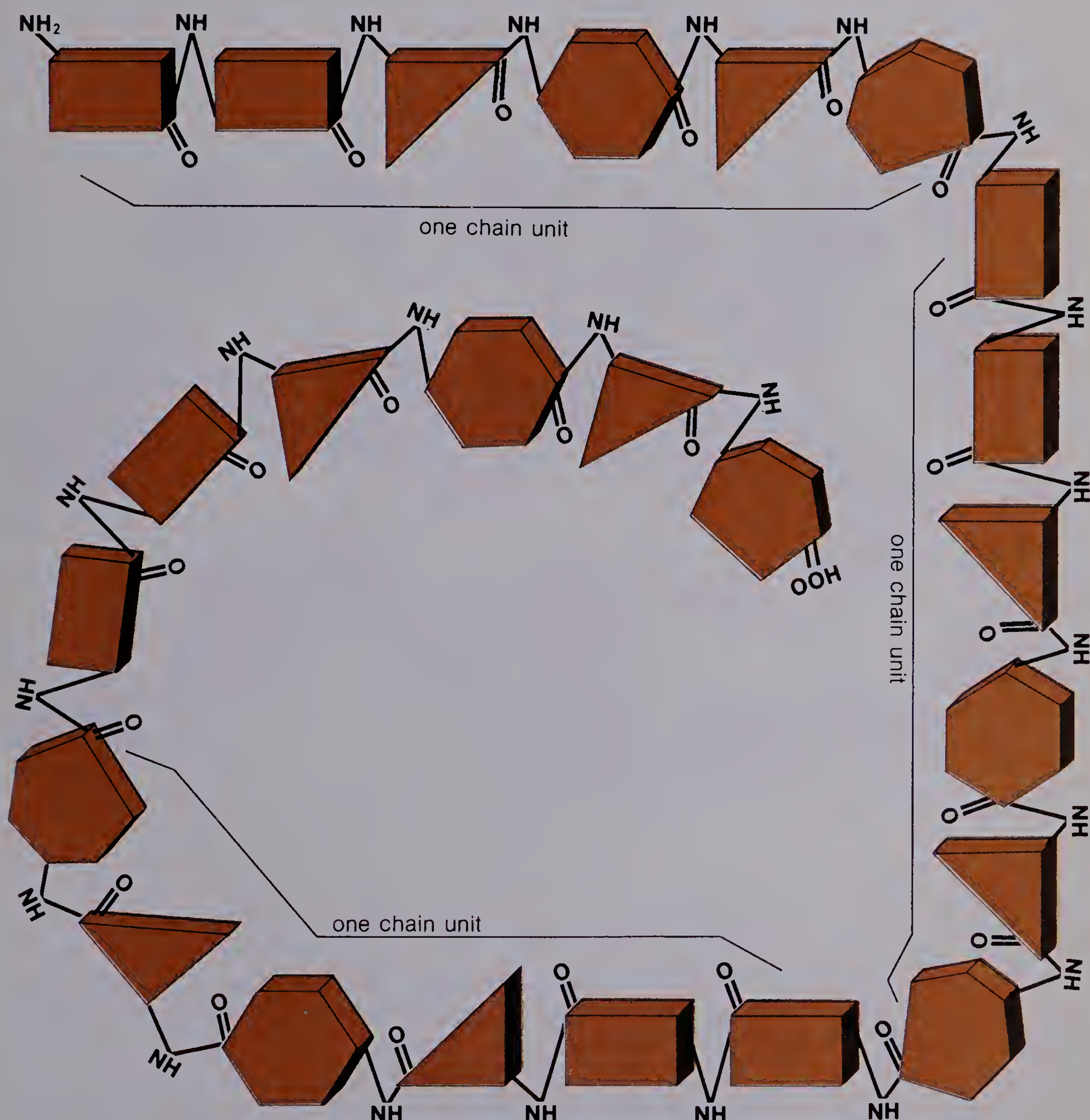


Figure 11–3

As shown in Figure 11–3, the joining of two amino acids results in the formation of water. Water is released whenever amino acids bond together.

As the amino acids link up, they form chains. Their exact arrangement in a chain determines the kind of protein being formed. Each protein consists of repeating chain units and contains thousands of amino acids.



Unlike starch molecules, the breakdown of large protein molecules requires an acid environment. Protein digestion, therefore, doesn't begin until food gets to the stomach, where hydrochloric acid is present. As well as providing a favorable environment, the hydrochloric acid is also necessary to activate the enzyme that breaks down proteins.

An inactive form of the enzyme *pepsin* is secreted by cells lining the stomach walls. Hydrochloric acid changes the inactive form to the active form. Through hydrolysis, pepsin breaks proteins down into their chain units.

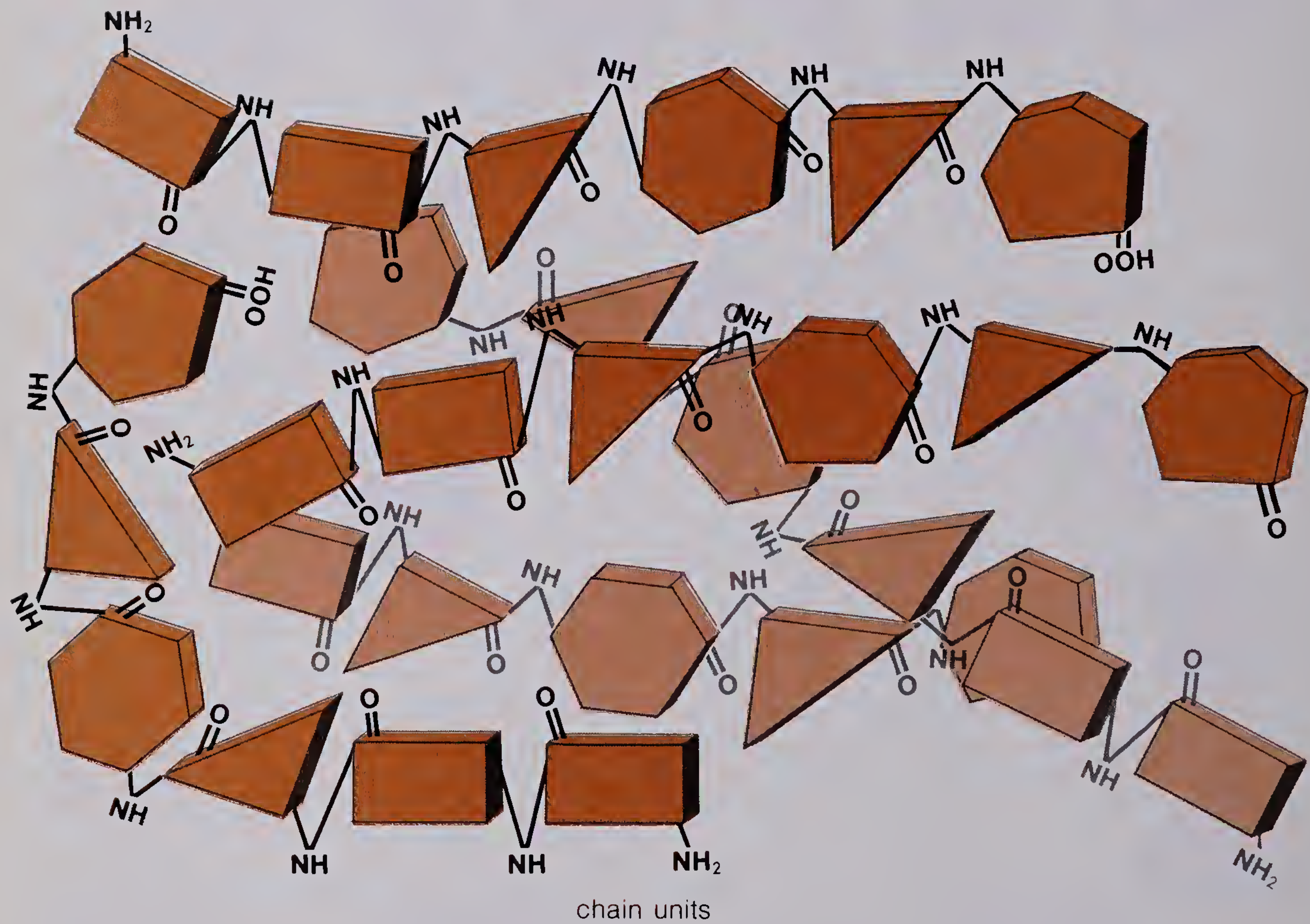


Figure 11–4

11-4. Pepsin, activated by stomach acid, splits the protein into long chains of amino acids.

★ 11–4. Describe the process of protein digestion in the stomach. What are the products of this digestive reaction?

Further digestion is necessary in the small intestine to release the individual amino acids from the chain units. This happens in an alkaline environment. Look at Figure 11–5.

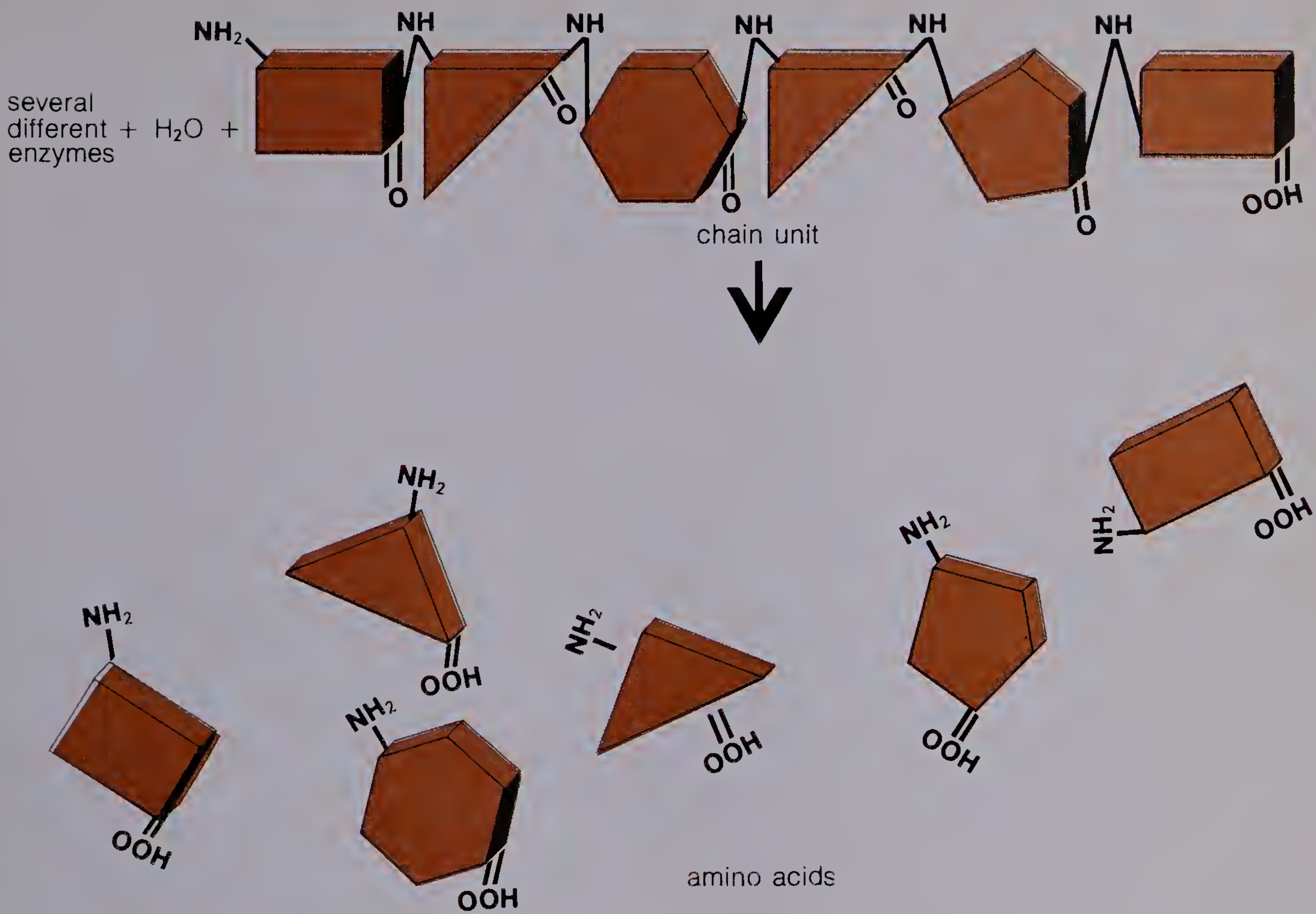


Figure 11–5

✓ 11–5. What must be present to release amino acids from the chain units?

11-5. Water and several different enzymes.

As mentioned before, enzymes are specialists. Each enzyme hydrolyzes bonds in a specific chemical environment and will do so in no other environment. So, to complete protein digestion in the small intestine, enzymes other than pepsin are needed. And why several different enzymes? Because some will hydrolyze bonds only at the ends of chains while others hydrolyze the bonds within.

Through the combined action of enzymes, then, a protein is digested into fragments of various lengths and finally into free amino acids. The free amino acids can be absorbed through the walls of the intestine. Inside the body, the amino acids are rejoined into proteins that can be used by the body. This includes the making of enzymes, which happen to be proteins.

★ **11–6. What does the statement "enzymes are specialists" mean?**

11-6. They attack only particular kinds of bonds in certain specific kinds of molecules in a specific chemical environment.

excursion

Activity 12 Planning

Gone Tomorrow?

Activity 13 Page 63

Do you, like most people, get cavities? Have you ever wondered why? Find out why in this activity, and learn what weapons you have against tooth decay.

Comparing Guts

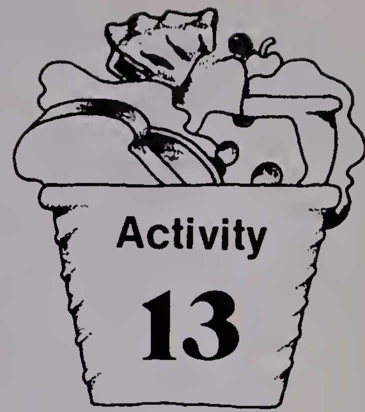
Activity 14 Page 71

By examining a dissected frog, crayfish, earthworm, and pig, you can learn a lot about yourself. Give it a try—it's not so bad once you start.

ACTIVITY EMPHASIS: Plaque can cause gum disease and cavities, if not removed.

Gone Tomorrow?

Students investigate acidity of the mouth from sugar and amount of plaque on teeth.



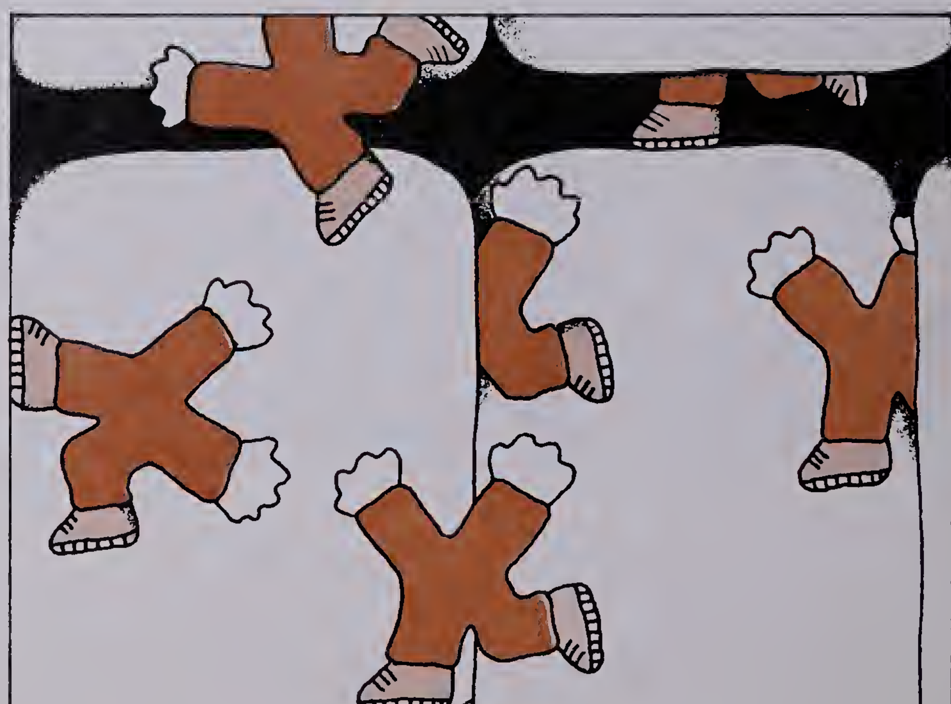
Have you ever seen people with some or all of their teeth missing? How does it happen? Could it happen to you?

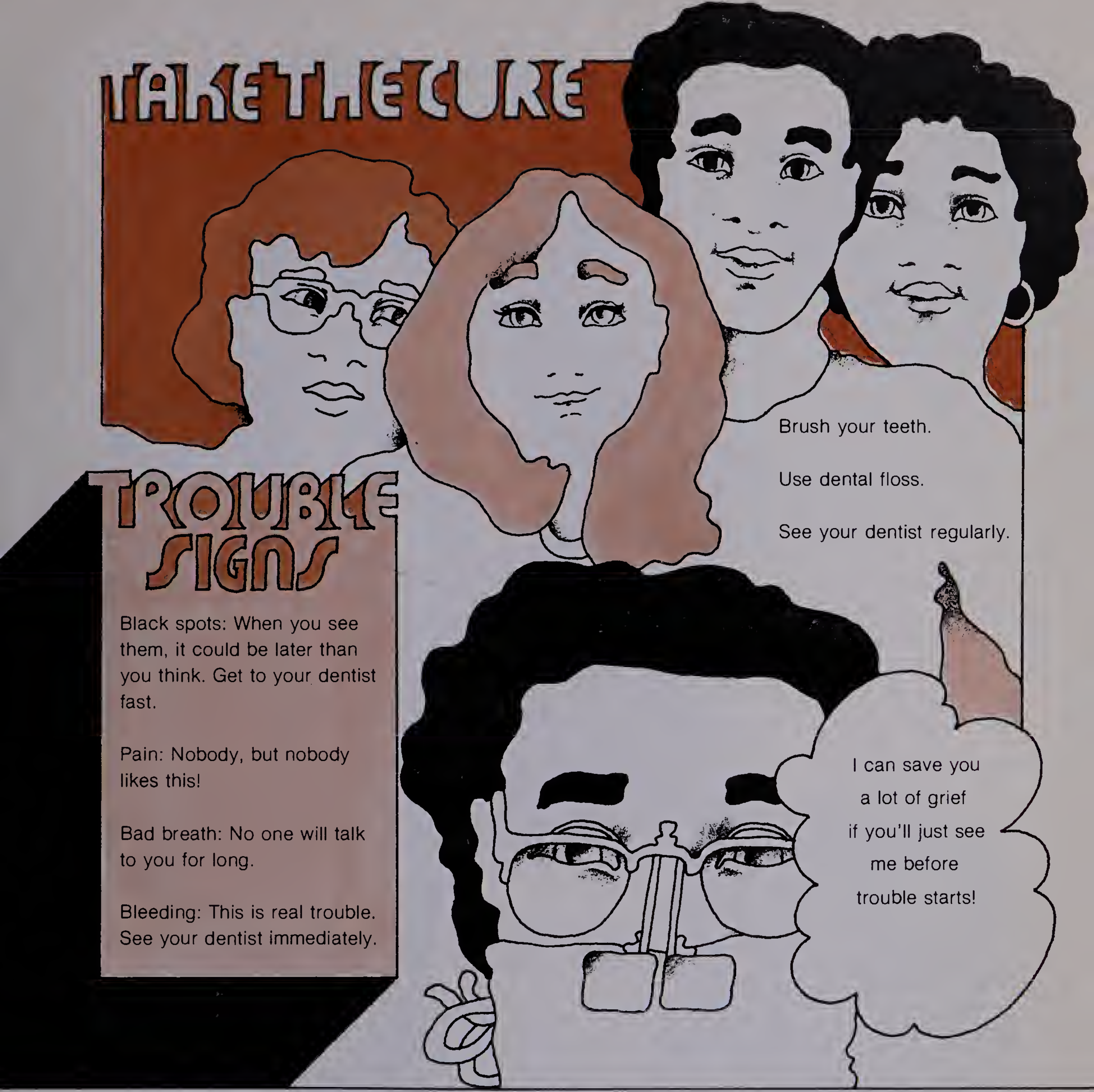
Well, when you've had a snack, like a sandwich and a "tall cool one," bacteria like it too. They attach themselves to your teeth and combine with juices in your mouth. This combination of bacteria and juices forms a sticky, colorless film called *plaque* [PLACK].

MATERIALS PER STUDENT UNIT

pH test paper and dispenser
spoon
granulated sugar, 5 ml
plaque-disclosing tablet
mirror
toothbrush
toothpaste
Resource Unit 7

Some of the bacteria in plaque act on the sugary part of your snack. The actions of those bacteria produce acids that can dissolve the enamel, or the protective covering, of your teeth.





Bacteria don't attack teeth, but the acids produced by the bacteria do. Acids are produced when the bacteria feed on the food around the teeth—food stuck in the grooves on teeth and food stuck between the teeth and the gums. Plaque contains bits of food, bacteria, bacterial acids, and saliva.

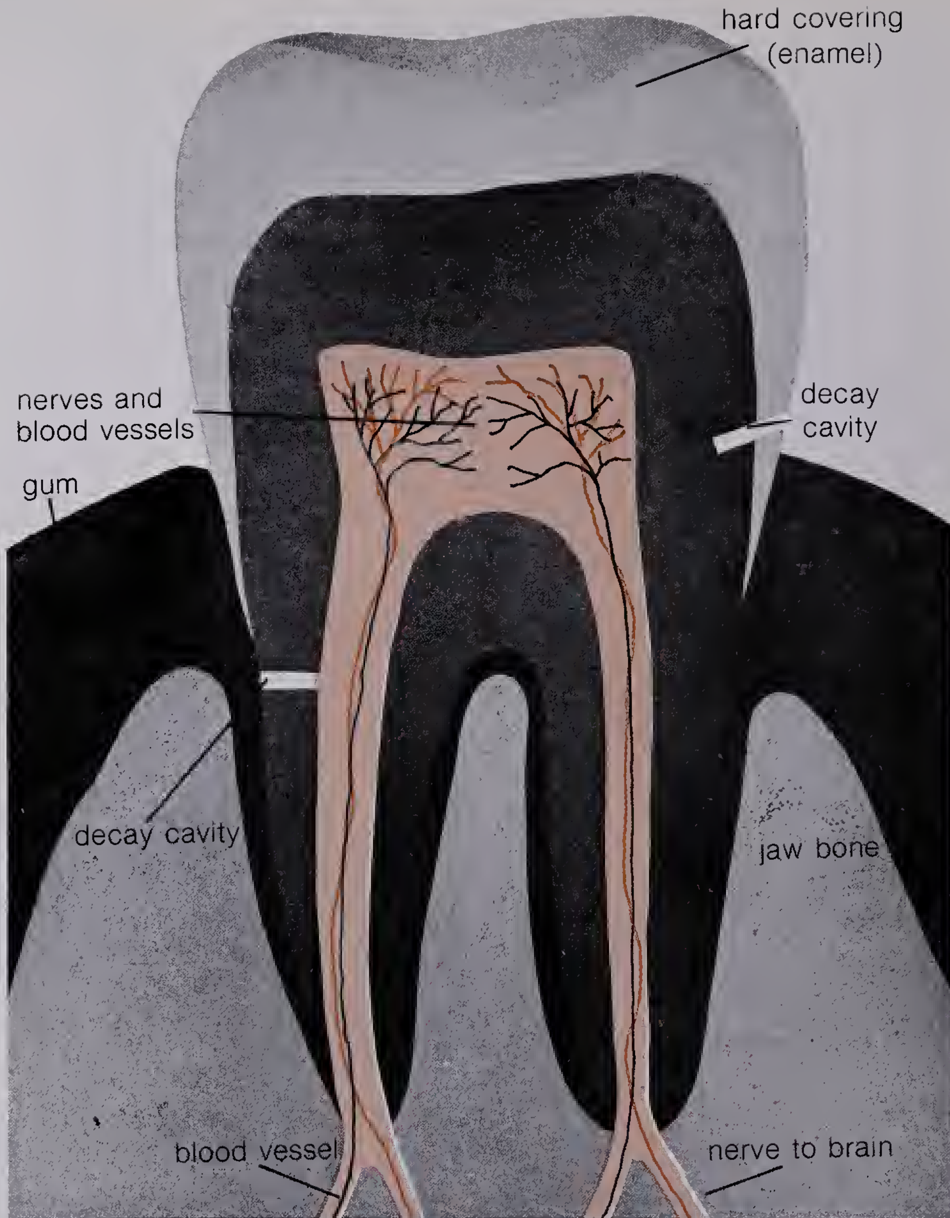


Figure 13–1

13-1. Plaque is a combination of bacteria and mouth juices found on teeth. The bacteria produce acids that attack teeth.

★ 13–1. What is plaque? How can it harm your teeth?

The enamel on your teeth is very strong, but not strong enough to resist the acids in plaque. There might not be much acid in your mouth right now. It all depends on how long ago you brushed your teeth or ate or drank something.

Some foods increase the amount of acid in your mouth. To see this, you will need the following materials:

pH test paper and dispenser with color-code chart
spoon
granulated sugar

A. Touch a piece of pH paper, about 2 cm long, to a moist section of your mouth. Compare the color of the pH paper with the color chart on the dispenser.

✓ 13–2. What is the pH of your mouth? (If you don't understand pH, see *Resource Unit 7.*)

13-2. 6 or 7.

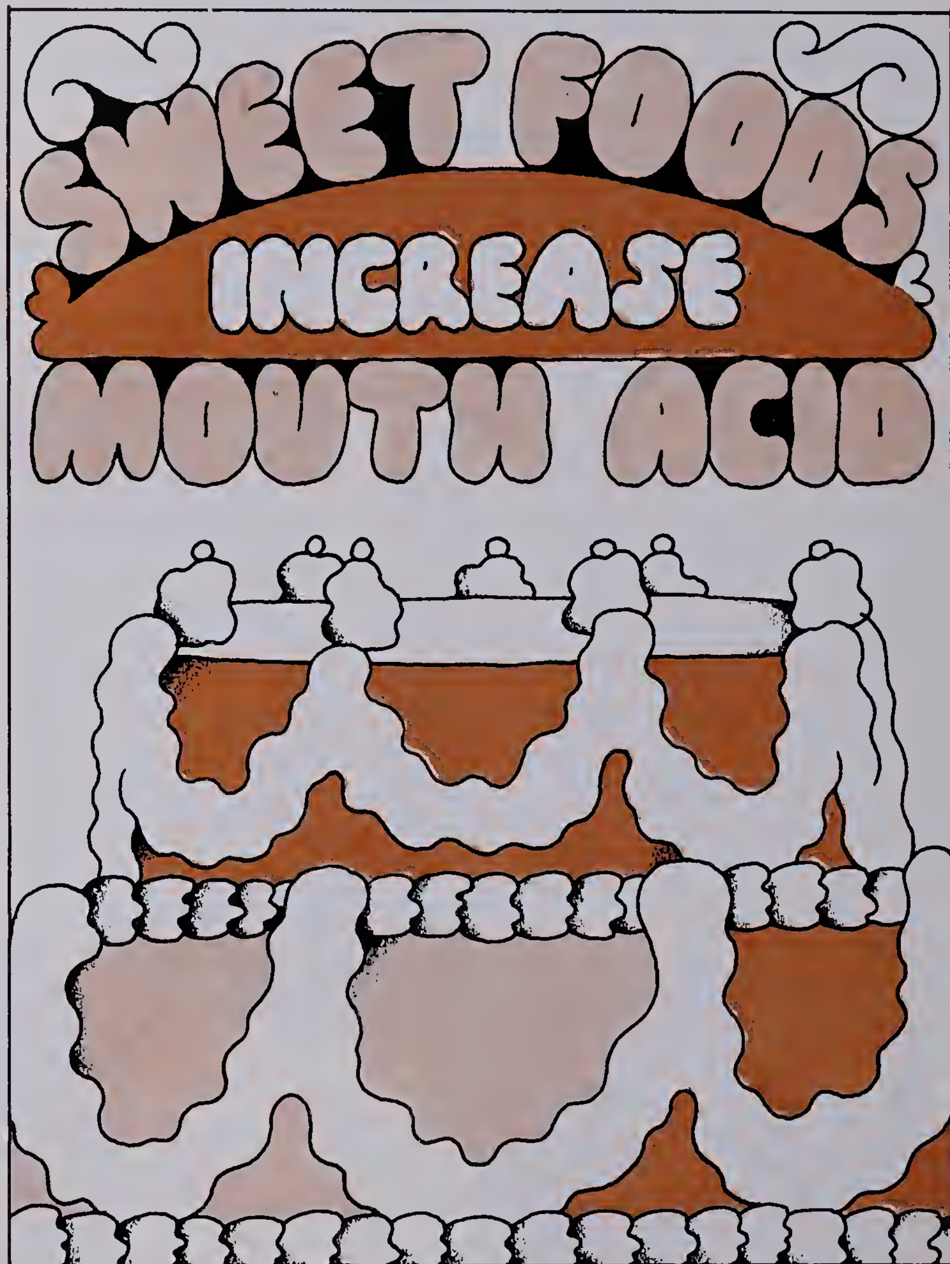
Have *Resource Unit 7* available to aid students in understanding pH.

B. Put some sugar in your mouth and let it dissolve there before you swallow it. Wait a few minutes, then find the pH of your mouth.

13-3. Answers will vary, but should be 2 to 4.

✓ 13–3. What is the pH of your mouth after eating sugar?

Saliva helps keep your mouth at a neutral pH, or about 7, but—



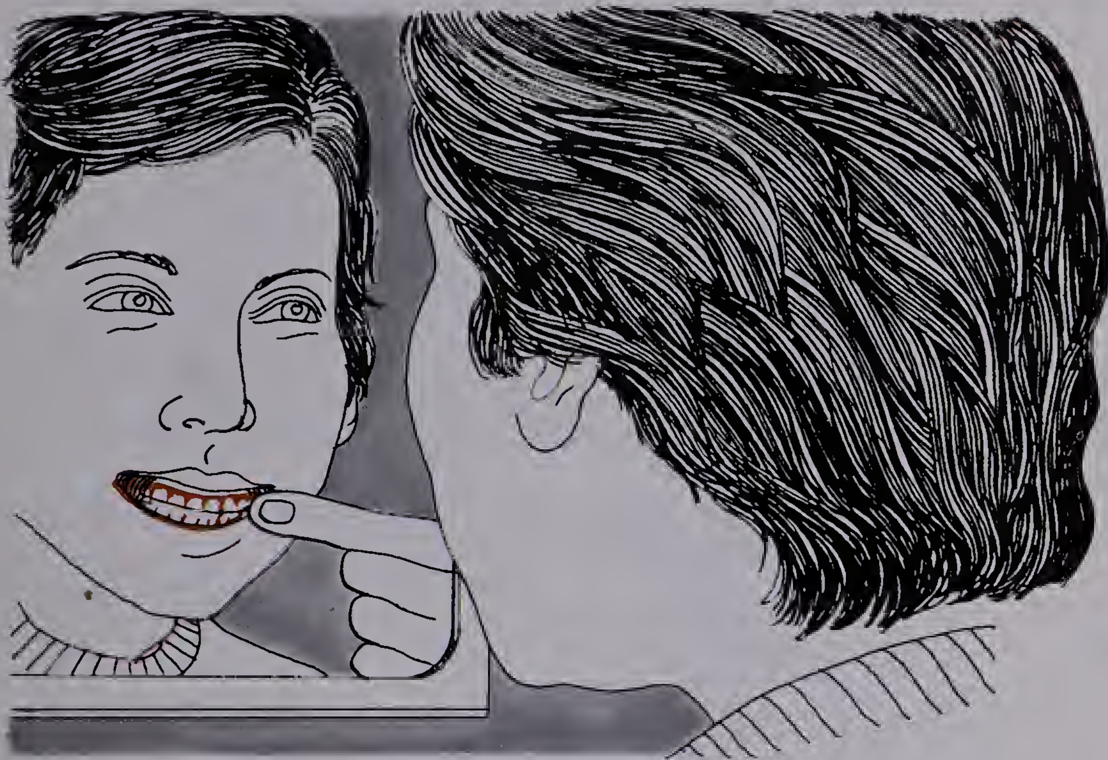
Acids eat away at your teeth. And bacteria in plaque produce the acids. To see how much plaque you have on your teeth, you will need the following items:

plaque-disclosing tablet
mirror
your own toothbrush
toothpaste

A. Chew a plaque-disclosing tablet and swish the solution between your teeth. Then rinse out your mouth and examine your teeth in a mirror.

✓ 13–4. Where is most of the plaque on your teeth?

13-4. Between teeth.



B. Brush your teeth, especially where there is red dye.

Red dye is harmless and will fade away.

Gums can be damaged if flossing is not done correctly.

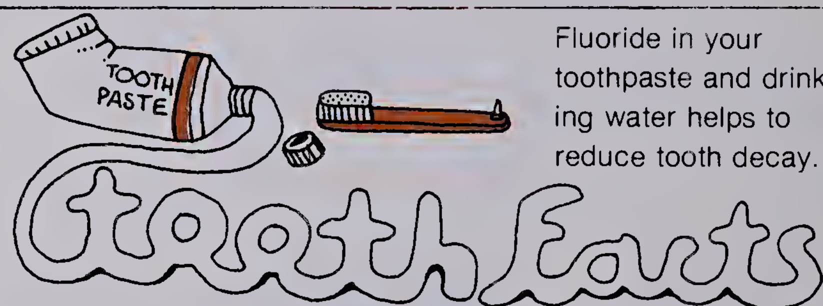
★ **13-5. Does brushing help get rid of plaque? Where does brushing do the best job?** 13-5. Yes; on the front surfaces of teeth.

Because it is difficult to brush between your teeth, plaque builds up there. Dental floss is helpful for getting at that hard-to-reach plaque. If you haven't been shown how to use dental floss properly, ask your dentist to show you. It's important to floss every day.

★ **13-6. Where does flossing do the best job in getting rid of plaque?** 13-6. Between teeth.

When plaque is allowed to remain on teeth, it hardens and attaches itself firmly to the teeth. Hardened plaque is called *tartar.* When tartar builds up around the gum line, it can cause the gums to get red, swell, and feel hot. If you let that condition go on too long, you might lose your teeth to gum disease.

★ **13-7. What stuff in your mouth is responsible for cavities and gum disease?** 13-7. Plaque.



Fluoride in your toothpaste and drinking water helps to reduce tooth decay.

Gums are as important as teeth. If the gums go bad, your teeth will drift, and that messes up chewing.

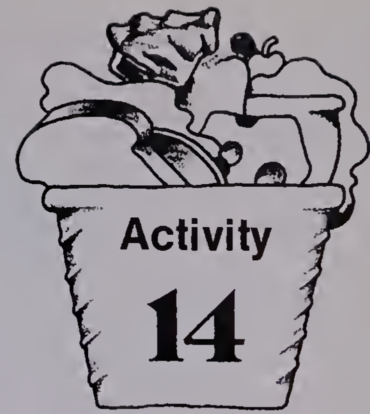
By the time people are in their late twenties, two out of three have lost some permanent teeth.

In the last fifty years, twenty million people have lost their teeth from gum disease.

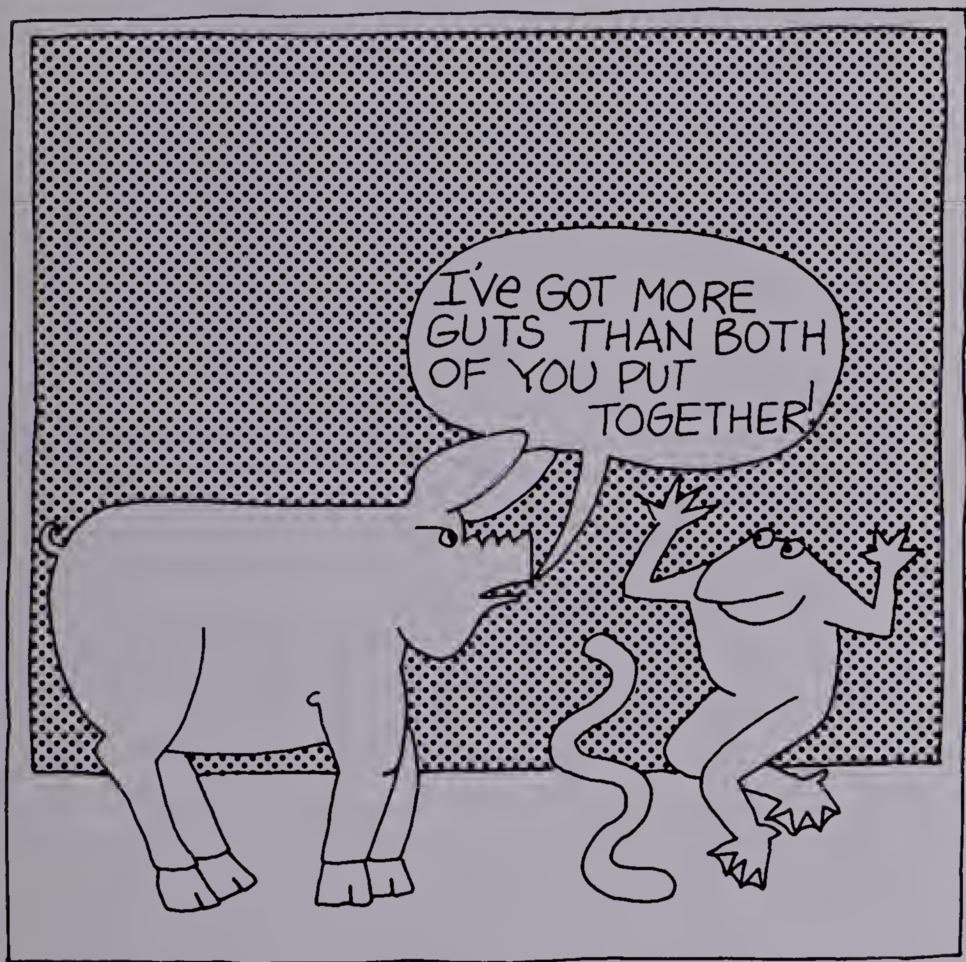
By the age of fifteen, four out of five people have minor gum problems.

Flossing helps get rid of plaque between teeth and between teeth and gums.

Comparing Guts



In this activity, you will look at the digestive systems of several organisms and compare them with what you know about your own. You should allow about two days for this activity.



ACTIVITY EMPHASIS: Human digestive system is similar in some ways to that of the frog, crayfish, earthworm, and pig. Students examine at least one dissected animal.

MATERIALS PER STUDENT UNIT
At least one of the following:
dissected earthworm
dissected crayfish
dissected frog
dissected fetal pig
dissection probe
hand lens

To see how other digestive systems are similar and different from your own, you will need a dissection probe, a hand lens, and at least *one* of the following:

dissected earthworm attached to a pan
dissected crayfish attached to a pan
dissected frog attached to a pan
dissected fetal pig attached to a pan

See Advanced Preparation, p. TM 8, for details on the dissections.

Before beginning, copy the chart in Figure 14–1 into your notebook.

DIGESTIVE SYSTEMS

PARTS	EARTHWORM	CRAYFISH	FROG	FETAL PIG	HUMAN
Mouth opening	✓	✓	✓	✓	✓
Lips			✓	✓	✓
Teeth			✓	✓	✓
Tongue			✓	✓	✓
Esophagus	✓	✓	✓	✓	✓
Stomach	✓	✓	✓	✓	✓
Folds inside stomach			✓	✓	✓
Small intestine	✓		✓	✓	✓
Folds inside small intestine			✓	✓	✓
Pancreas			✓	✓	✓
Liver			✓	✓	✓
Gall bladder			✓	✓	✓
Large intestine		✓	✓	✓	✓
Rectum				✓	✓
Anal opening	✓	✓	✓	✓	✓

Figure 14–1

Get one of the dissected specimens. Try to locate each of the parts of the gut listed in the chart. As you find a part, check it off in the chart.

Repeat the procedure for each of the remaining dissected specimens. The specimens should look similar to those shown in this activity. For any specimen you can't get, use an illustration. For the column titled "Human," you may want to review Activity 2 before checking off the parts.

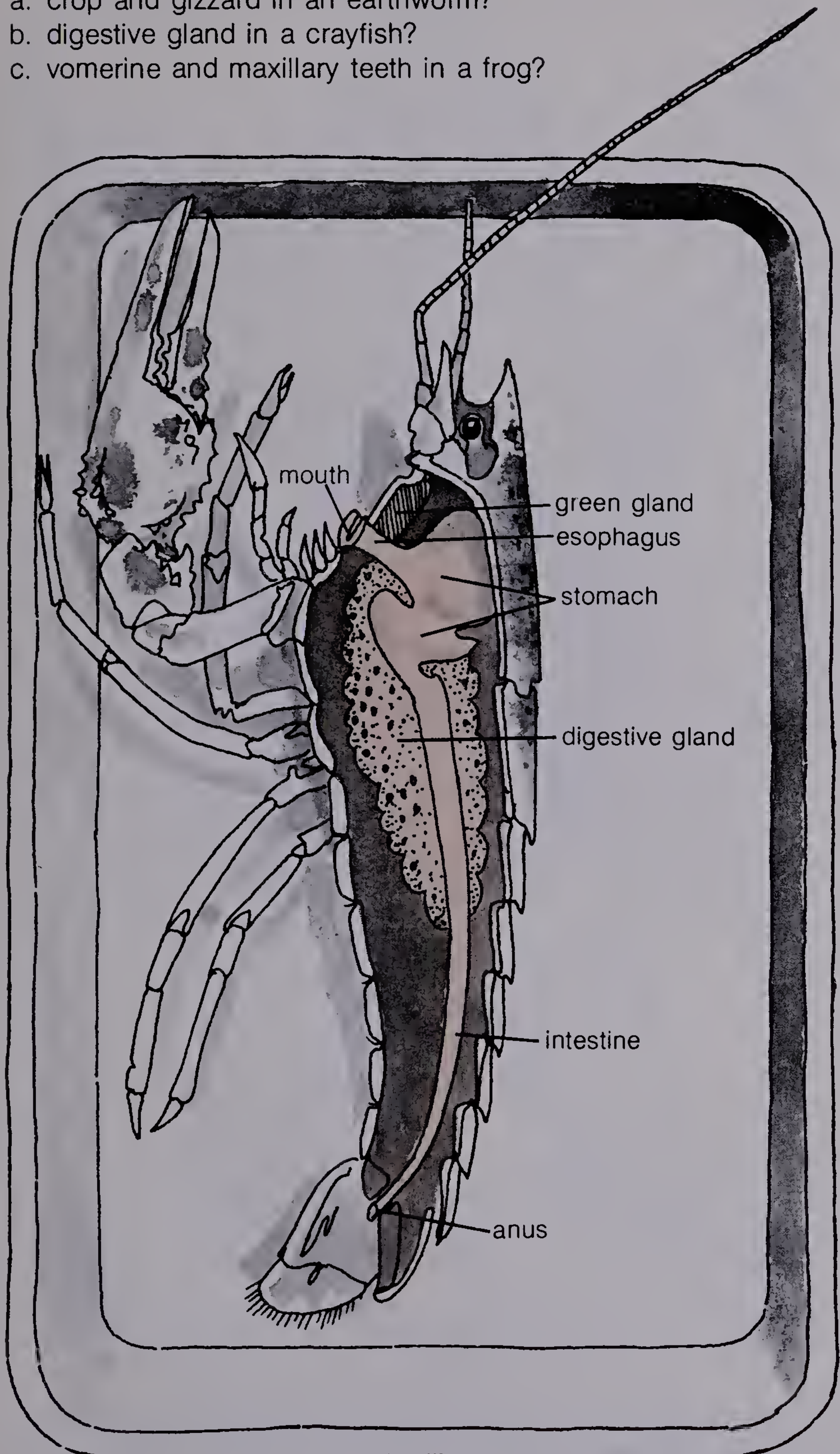
14-1. Earthworm or crayfish; It doesn't have teeth, tongue, pancreas, liver, gall bladder, nor folds inside the stomach and small intestine.

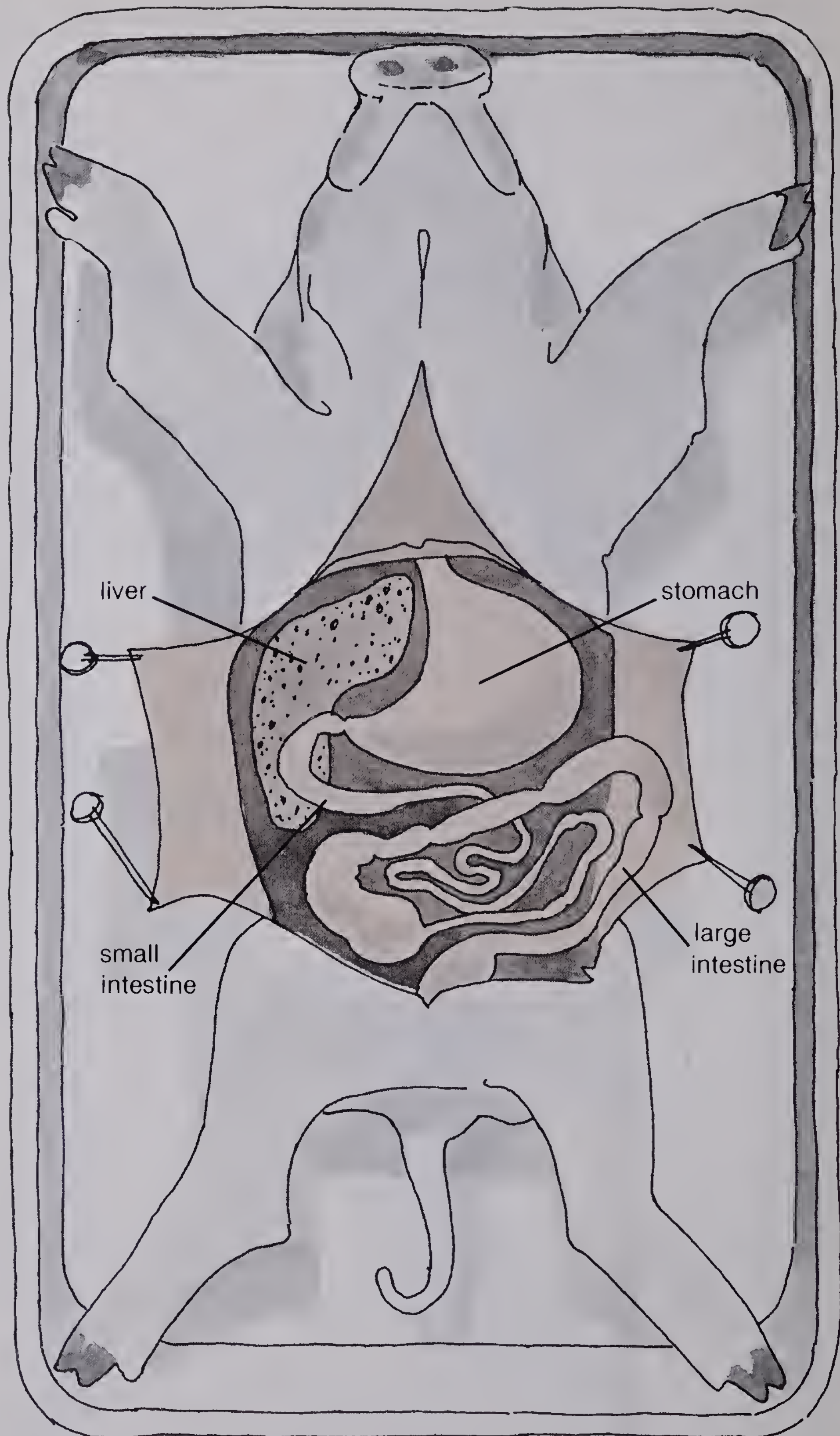
✓ 14-1. Which specimen has a gut most unlike your own? What makes you think so?

✓ 14-2. Which specimen has a gut most like your own? What makes you think so? 14-2. Fetal pig; The digestive system is the same except for the lack of folds in the stomach and small intestine.

✓ 14–3. Which of your digestive parts is similar in function to the
a. crop and gizzard in an earthworm?
b. digestive gland in a crayfish?
c. vomerine and maxillary teeth in a frog?

14-3. a. Stomach.
b. Small intestine.
c. Teeth.





14-4. Earthworm: Similar in having mouth, esophagus, and anus, but has no teeth, tongue, nor liver.

Crayfish: Similar in having mouth, esophagus, and anus, but has no teeth, tongue, nor folds in intestine.

★ 14–4. Choose an earthworm, or a crayfish, and describe three similarities and three differences between the gut of that animal and your own.

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The ISIS Project is an intricate effort involving many people in many roles. The following individuals have made significant contributions to that effort.

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